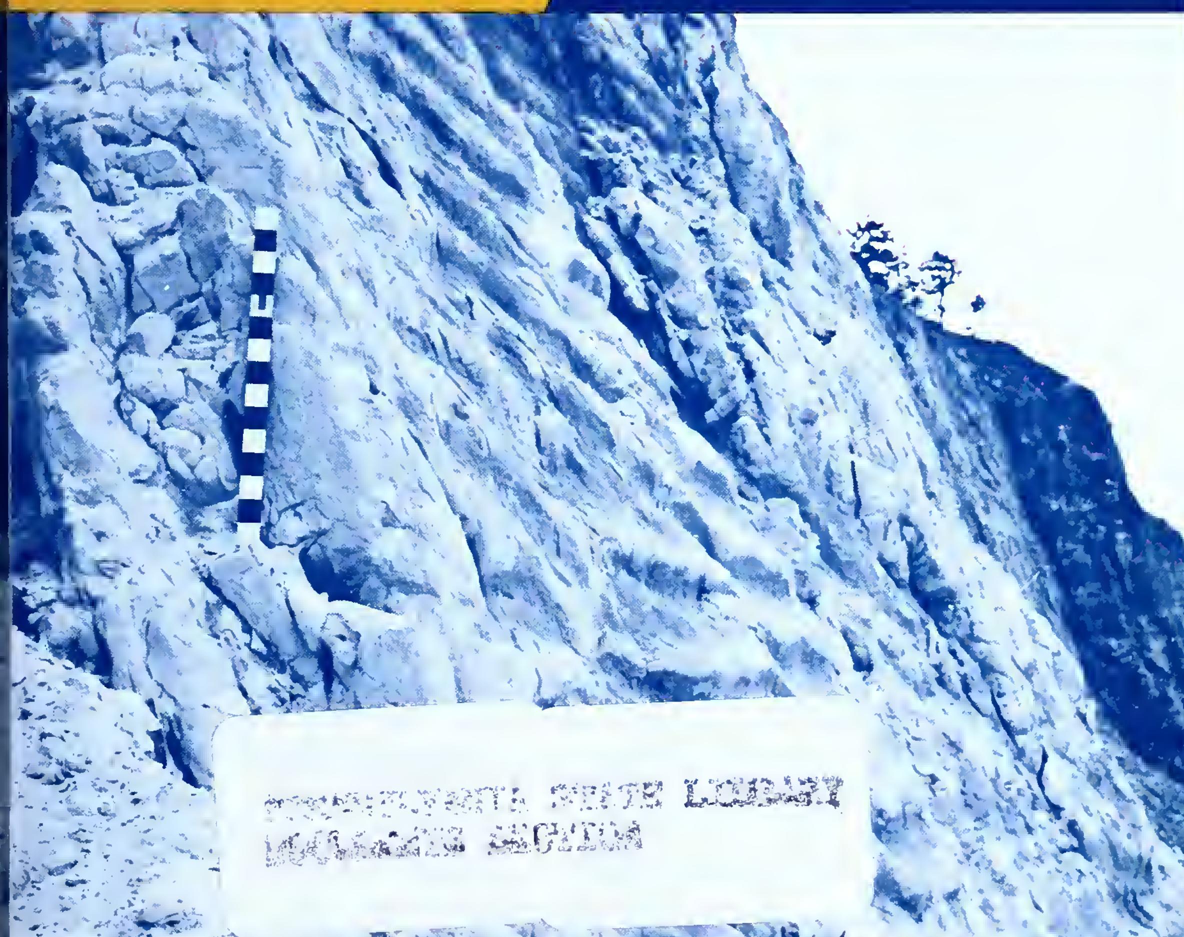
Vols 12-13, 1981-82

PENNSYLVANIA GEOLOGY



THE PENNSYLVANIA GEOLOGICAL SURVEY VOL. 12/1

COMMONWEALTH OF PENNSYLVANIA
Richard L. Thornburgh, Governor

DEPARTMENT OF ENVIRONMENTAL RESOURCES
Clifford L. Jones, Secretary

TOPOGRAPHIC AND GEOLOGICAL SURVEY
Arthur A. Socolow, State Geologist

CONTENTS

ON THE COVER: Giant, water-formed ripple marks on ancient sandstone near Fayetteville, southeastern Franklin County. Ripples are up to a foot high and three feet from crest to crest. (See article in this issue.) Photo courtesy of J. P. Wilshusen.

PENNSYLVANIA GEOLOGY is published bimonthly by the Topographic and Geologic Survey, Pennsylvania Dept. of Environmental Resources, Harrisburg, Pennsylvania, 17120.

Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

FEBRUARY 1981

FROM THE DESK OF THE STATE GEOLOGIST

TWO RIGHTS DON'T MAKE A WRONG

In recent months there has been a marked increase in the number of new oil and gas wells being drilled in Pennsylvania. While 2,199 new wells were drilled in 1980, many more are expected in 1981, based on the drilling permits which have been issued in the last few months. This results from the economic stimulus of rising prices for oil and natural gas.

To many citizens the increased exploration and drilling is seen as offering Pennsylvania a hope for greater energy self sufficiency, with resulting benefits to our industry and our economy. And these optimistic citizens are right.

Other citizens view the increased oil and gas drilling with alarm, because they see that some of the new drilling results in new access roads which in places can get very muddy, and this construction may also cause a loss of some trees. Such practices have recently been publicized in the press. These concerned citizens are also right.

But oil and gas development need not be an "either-or" situation in relation to environmental quality. Responsible industry can and does abide by environmental laws and regulations. Those few, irresponsible operations which are violators will be addressed under the provisions of the Clean Streams Act, the Environmental and Sediment Control Law and the Oil and Gas Act. To ensure that these provisions of environmental safeguard are effectively operative, DER Secretary Clifford Jones has appointed an Oil and Gas Environmental Advisory Committee made up of representatives of public environmental organizations and of oil and gas industry operators. The concerned public, for their part, must recognize that the owner of oil and gas rights on a property does have a legal right of "reasonable access" to drilling sites, and "reasonable" may include a certain amount of road access and related construction impacts.

We can't deny that wherever man has tread he has had an impact on the pre-existing natural environment. This is even true in housing developments and recreation areas. Man himself is a part of our environment, as are man's food and energy resources. With proper industry respect for our environment and for the laws which have been passed to protect it, we can have reasonable access to the oil and gas energy resources we have been blessed with. And with an equal recognition that legally acquired oil and gas rights carry a legal right of reasonable access, we should be able to operate under fair and equitable rules of procedure; we can protect the environment and have our energy too. Both sides of this issue are right; with recognition and tolerance we should be able to proceed with our energy resources while still respecting the environment.

Arthur A. Socolow

CORRECTION: In the October, 1980 issue of PENNSYLVANIA GEOLOGY the State Geologist's article on page 1 incorrectly read "96.3 million cubic feet of natural gas was taken out of the ground in Pennsylvania in 1979." The correct figure is 96.3 *billion* cubic feet. That's quite a difference; we regret the error.

GIANT RIPPLES AT MOUNT CYDONIA

by J. P. Wilshusen and W. D. Sevon

A magnificent exposure of huge, ancient sand ripples (megaripples) (Figure 1) is presently exposed in an active quarry of the Mount Cydonia Sand Company near Fayetteville in southeastern Franklin County, Pennsylvania. These megaripples occur near the middle of the Early Cambrian Antietam Quartzite which is exposed along the north side of South Mountain (Figure 2).

The Antietam Quartzite at Mount Cydonia is a clean, coarse-grained, quartzose sandstone. The sand grains are almost entirely subangular to well-rounded quartz grains, accompanied by rare grains of chert. Quartz overgrowth on the grains are common and these, as well as intergranular quartz, serve as the binder for the rock. The formation has two lithologic subdivisions. The lower part is a resistant, bluish to pink quartzite which varies from structureless, to planar bedded, to thin beds with small-scale, multi-directional cross-bedding. The upper part consists of white to pinkish sandstone containing abundant *Skolithos* tubes (fossil animal burrows). The prominent megarippled surface (Figure 1) is the approximate boundary between the two rock varieties. The Antietam is about 800 feet thick in the quarry and varies regionally from 700 to 900 feet thick (Stose, 1932).

The Antietam Quartzite was folded during the post-Ordovician period mountain building which formed the South Mountain anticlinorium and gave the present 70° northwest dip to the megarippled beds. This deformation also imparted to the Antietam a spaced cleavage which dips perpendicular to the bedding and strikes approximately parallel to bedding.

The trace fossil *Skolithos linearis* (Figure 3) occurs in profusion in the upper part of the Antietam and superb examples can be seen in unquarried rock faces and in numerous quarried blocks. A trace fossil is a fossilized track, burrow, or boring which resulted from the activities of an animal. The morphology of the animal which made the trace is unknown because the animal probably had no hard parts which could be fossilized.

In weathered rock *Skolithos linearis* appears as a remarkably straight, sand-filled tube which has a circular cross section. These tubes are prominent on weathered surfaces because of differential weathering of the apparently less well-cemented tube. In fresh rock

Figure 1. Corrugated surface of megaripples in Lower Cambrian Antietam Quartzite.

Skolithos is not readily discernable. These tubes are thought to have been formed by a worm that lived in the tube and may have fed at or near the sediment-water interface. *Skolithos linearis* is found almost exclusively in sandstones and is one of a suite of trace fossils interpreted to be associated with dominantly high energy shallow marine depositional environments such as offshore bars and beaches and, to a lesser degree, deeper offshore sediments (Banks, 1970). Its presence, as well as rare marine fossils reported from other localities (Fauth, 1968), establishes a marine origin for the Antietam Quartzite.

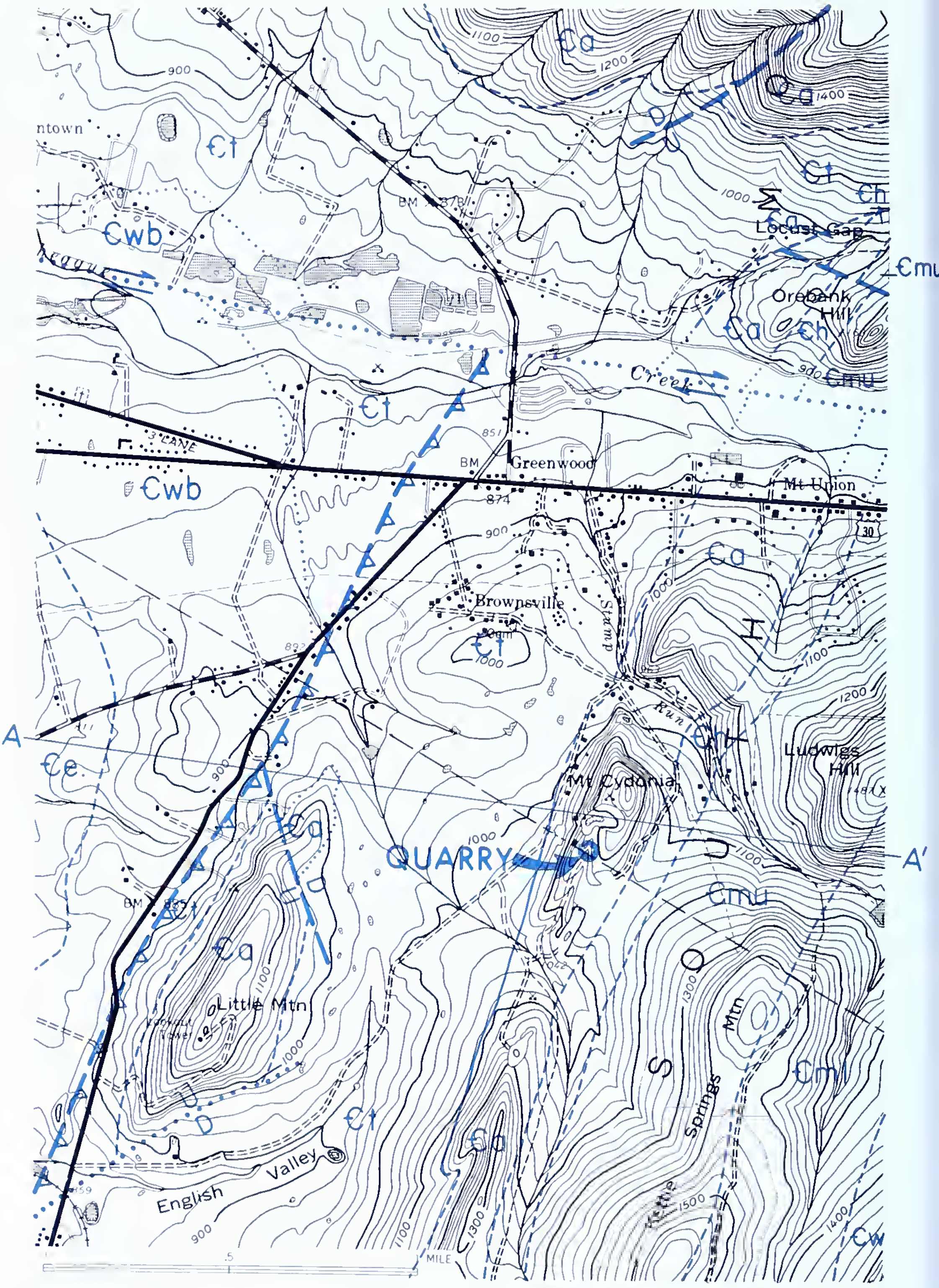


Figure 2. Geologic map and cross section.

LEGEND

Ꞓe

ELBROOK FORMATION

Gray limestone and calcareous sandstone with finely laminated, shaly limestone in lower half.

Ꞓwb

WAYNESBORO FORMATION

Bluish limestone and dolomite with interbedded sandstone and shale.

Ꞓt

TOMSTOWN FORMATION

Gray dolomite with interbeds of white limestone.

Ꞓa

ANTIETAM QUARTZITE

White to gray, medium- to coarse-grained sandstone and quartzite.

Ꞓh, Ꞓmu, Ꞓml

HARPERS FORMATION

Greenish-gray graywacke, Harpers Formation (Ꞓh); light-gray sandstone and quartzite, Upper Montalto Member (Ꞓmu); gray, thin-bedded sandstone and quartzite, Lower Montalto Member, (Ꞓml).

Ꞓw

WEVERTON FORMATION

Interbedded sandstone and graywacke with conglomerate and phyllite intervals.

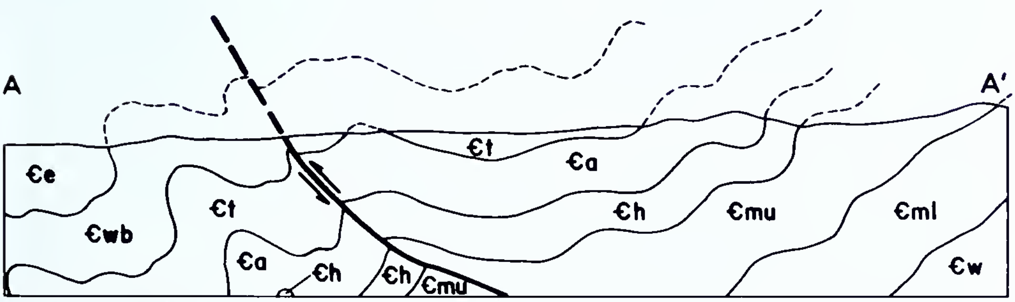
SYMBOLS

Thrust fault

A —————— A′

Line of cross section

CROSS SECTION



Scale: Same as map
No vertical exaggeration

From Fauth, 1968

Figure 3. The trace fossil *Skolithos linearis* appears as narrow gray stripes approximately parallel to the hammer handle in this quartzite boulder. *Skolithos linearis* is always perpendicular to bedding.

The megaripples which occur below the zone of *Skolithos* tubes have heights (amplitudes) of 5 to 10 inches and wave lengths of 18 to 30 inches (cover and Figure 1). The megaripples are asymmetrical in cross section and have unidirectional forset layers which dipped northwest prior to folding. Individual megaripples are laterally persistent and vary from linear to slightly sinuous (Figure 4). The crests of the megaripples are rounded. Other beds near the megaripple horizon have rippled surfaces (Figure 5) but the ripples are smaller in scale. These ripples also have northwest dipping forset laminae.

Megaripples are formed in sand under water by any of three mechanisms: (1) by unidirectional flow of water, such as in a stream, (2) by oscillatory motion of waves in shallow waters of oceans or lakes, and (3) by combination of (1) and (2), such as in a tidal channel. A wave-generated origin in which oscillatory flow is stronger in one direction, generally landward, than the other seems probable for the Mount Cydonia megaripples. Such an interpretation seems

Figure 4. Steeply dipping bedding plane surface of megaripples exposed in the Mount Cydonia Sand Co. quarry, Franklin County. Scale is 1½ meters long.

Figure 5. Two rippled bedding surfaces several feet below the major surface shown in figures 1 and 4.

particularly reasonable because the megaripples occur between the lower part of the Antietam, which has sedimentary structures probably formed in ancient offshore environments below non-storm wave base, and the upper part, which certainly represents ancient nearshore deposition. Thus the megaripples represent wave-generated ripples formed during shallowing of water at a time of deposition of Antietam sands.

Whether or not these megaripples formed along the real coast of the continent in Early Cambrian times or along barrier islands fronting the continent (Kauffman and Frey, 1979) is not known. However, acceptance of a wave-generated origin for the megaripples and a landward dip for their forset layers supports the concept that the source area for the Antietam Quartzite lay to the northwest and that the development of the southeastern source area which dominated most of Paleozoic deposition in Pennsylvania occurred after deposition of the Antietam Quartzite.

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adams county groundwater resources study completed- lebanon and fayette counties study started

Larry E. Taylor and Denise W. Royer, hydrogeologists with the Bureau of Topographic & Geologic Survey, have recently finished a

study of the groundwater resources of Adams County; the results of which will be presented in a report (W-52) scheduled for publication in mid-1981.

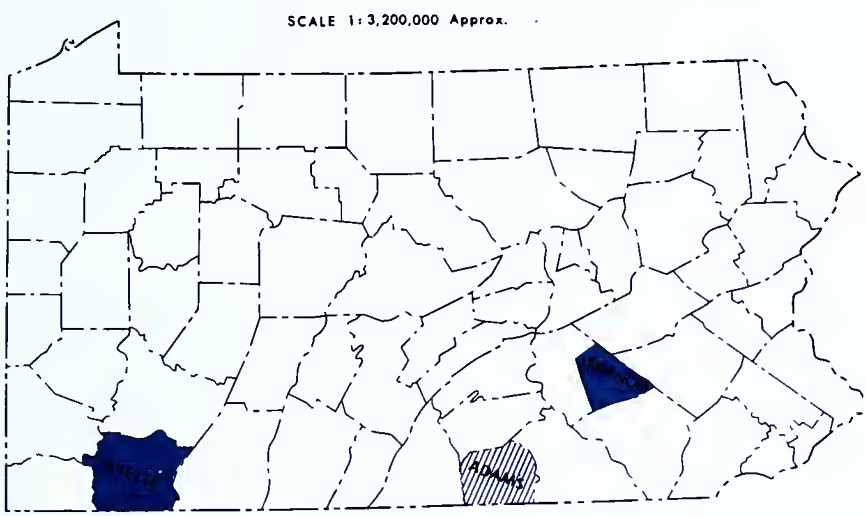
The project utilized groundwater information and interpretations from two previously completed detailed studies on the New Oxford Formation (W-21) and the Gettysburg Formation (W-49), in addition to new groundwater data collected throughout the county. The water well records presented in the report are now open-file and may be viewed at the Survey offices in Harrisburg.

The report will describe the occurrence and availability of groundwater as related to geology, topography, and climate. The natural or existing groundwater quality is also described.

A similar groundwater study has been started recently in Lebanon County by Denise W. Royer. This study will utilize previously completed hydrologic reports for the Lebanon Valley carbonates (W-18) and the Hammer Creek Formation (W-49). New groundwater information will be collected primarily in the northern part of the County.

A study of the groundwater resources of Fayette County was recently started by Survey hydrogeologist Thomas McElroy. The project has two primary objectives. The first is to provide a comprehensive description and inventory of the groundwater resources of Fayette County, enabling the planning of groundwater supplies and groundwater management. The second objective is to monitor groundwater quality in relation to coal mining. Because of the renewed emphasis on coal mining in southwestern Pennsylvania and the popular concern for the protection of groundwater supplies, the second objective is of particular interest.

The estimated completion date of the report is mid-1982.



EARTH SCIENCE TEACHERS' CORNER

new films

The following films were shown recently at the annual meeting of the Geological Society of America.

VENUS PIONEERS (27 min.)

This film uses animation and computer simulations to present information gathered by the Pioneer Spacecraft in 1978.

Dist: National Aeronautics and Space Administration, Code FVM, Washington, DC 20546

A NEW LOOK AT THE OLD MOON (28 min.)

This film reviews the geophysical and sample investigations during the period 1969 through 1979 to present the geological history of the moon.

Dist: A.V. Service Corporation, P.O. Box 58425, Houston, TX 77058, (713) 483-4231

CONTINENTAL DRIFT (22 min.)

Film outlines the processes of plate tectonics. Location footage, diagrams and animation are used to illustrate drifting, faulting, volcanism, earthquakes, and ridge formations.

Dist: Encyclopaedia Britannica Ed. Corp., 425 North Michigan Ave., Chicago, IL 60611, (312) 321-6800

DIVE TO THE EDGE OF CREATION (59 min.)

A mile and a half below the surface of the ocean, life exists in abundance around thermal vents. Discover worlds of life supported by bacteria that convert chemicals into organic matter.

Dist: Karol Media, E. 36A Midland Ave., Paramus, NJ (201) 262-4170

WATER: A PRECIOUS RESOURCE (23 min.)

An examination of the hydrologic cycle, water uses and environmental problems.

Dist: Karol Media

SECRETS OF LIMESTONE GROUNDWATER (25 min.)

Illustrates unusual nature of groundwater systems of carbonate rocks. Concentrates on development of Karst features and groundwater contamination.

Dist: Albert E. Ogden, University of Arkansas, Arkansas Water Resources Center, Fayetteville, AR 72701, (501) 575-4404

MOUNTAIN HERITAGE - THE APPALACHIANS (29 min.)

Evidence that the Appalachians were created by pre-Atlantic convergence is examined with Prof. John McGlynn in Newfoundland. Good geology.

Dist: Films, Inc., 1144 Wilmette Ave., Wilmette, IL 60091, (312) 256-4730

TELEDETECTION: REMOTE SENSING (25 min.)

Superb new film explaining (with excellent graphics and real-world examples) the essentials of Photography, side-looking radar, satellite imagery, and associated data processing. A good introduction to remote sensing—how it is done and what it is good for.

Dist: Available in English through Scientific Attache for Space Affairs, French Embassy, 2011 I Street, NW, Washington, DC 20006, (202) 658-3550

teacher's packets

Packets of earth science teaching aids prepared by the U.S. Geological Survey are available to teachers as a public service without charge. Each packet contains an assortment of general-interest leaflets and booklets related to earth science.

Packet #1—*Selected Packet of Geologic Teaching Materials*

This contains general-interest material selected for elementary and secondary school teachers of courses in environmental education, geography, oceanography, and social studies.

Packet #2—*Teacher's Packet of Geologic Materials*

This includes more specialized reference lists and materials for secondary school and college teachers of earth science courses.

Requests for packets should be in writing on school letterhead, specifying the subject or subjects you teach, grade level, and a self-addressed stick-on mailing label should be enclosed to expedite handling of your order. Mail requests to Branch of Distribution, U.S. Geological Survey, 1200 South Eads Street, Arlington, VA 22202.

SURVEY ANNOUNCEMENTS

REPORT ON PENNSYLVANIA'S OIL AND GAS

Pennsylvania oil production in 1979 totalled 2,816,682 barrels and natural gas production was 96,313 million cubic feet. While this represents a 1 percent decline over the prior year, the most encouraging development was a 6 percent increase in oil reserves (to 50,845,000 barrels) and a 7.5 percent increase in natural gas reserves (to 2,251,312 million cubic feet). This reflects the considerable increase in exploration and drilling for oil and gas during the past year.

These trends and statistics are included in the Bureau of Topographic and Geologic Survey's new publication on "Oil and Gas Developments in 1979." The 65-page report was compiled by Robert Piotrowski, former chief of the Oil and Gas Geology Division, with assistance from the division's staff; numerous tables, maps, and figures are included.

During 1979 the total number of new wells completed in Pennsylvania was 1941, an increase of 11 percent over the previous year. Drilling for natural gas leads this increase, with Indiana, Jefferson, Erie, Westmoreland, and Armstrong Counties showing the greatest amount of gas development. Oil drilling was greatest in Venango, Warren, and Forest Counties, accounting for 99 percent of all oil drilling in the Commonwealth, whereas McKean, Venango and Warren Counties lead in actual oil production.

Progress Report 193, "Oil and Gas Developments in Pennsylvania in 1979," is available from the State Book Store, P.O. Box 1365, Harrisburg, PA 17125. The price is $1.50 (plus 6% sales tax for Pennsylvania residents).

PAUL J. KUCSMA JOINS SURVEY

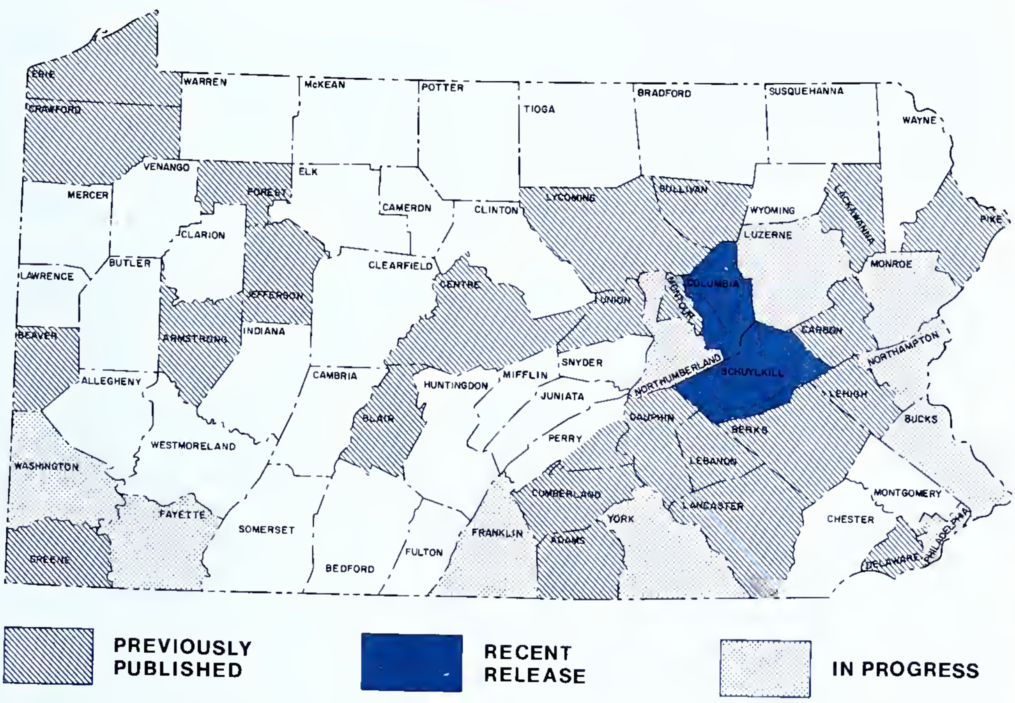
Paul J. Kucsma joined the Bureau of Topographic and Geologic Survey in August, 1980 as a geologist with the Division of Oil and Gas Regulation in Pittsburgh, Pennsylvania.

Mr. Kucsma received a B.S. in Geology from the University of Dayton in 1975 and an M.S. in Geology from Northeast Louisiana University in 1978. He spent one year working for GO Wireline Services as a Field Engineer in Lake Charles, Louisiana and a brief period as a consultant before joining the Survey.

Paul's duties include insuring compliance with the Oil and Gas Conservation and Gas Storage Acts, and other oil and gas projects as they develop to fulfill the responsibilities of that Division.

COUNTY TOPOGRAPHIC MAPS

During the past year, two new county maps have been completed and published as part of the ongoing cooperative topographic mapping program between the Pennsylvania Geological Survey and the U.S. Geological Survey. These are Columbia and Schuylkill (E and W sheet) Counties. Previously published maps include Adams, Armstrong, Beaver, Berks, Blair, Carbon, Centre (E and W sheet), Crawford, Cumberland, Dauphin, Delaware, Erie, Forest, Greene, Jefferson, Lackawanna, Lancaster, Lebanon, Lehigh, Lycoming (E and W sheet), Montour, Pike, Sullivan, and Union Counties. The maps are at a scale of 1:50,000 (approximately 400 feet to the inch). Counties currently in progress include Bucks, Fayette, Franklin, Luzerne, Monroe, Northampton, Northumberland, Philadelphia, Washington, and York.



These maps are multicolored, following the standard colors of the 7-1/2-minute topographic map series, with the addition of political boundaries for county, township and boroughs outlined in orange.

The county maps (with one exception) can be obtained for $2.00 per sheet by writing to Distribution Section, U.S. Geological Survey, 1200 South Eads Street, Arlington, Virginia 22202. The exception is the Lehigh County map which is available for $1.00 (plus 6¢ sales tax) from the Department of General Services, State Book Store, P.O. Box 1365, Harrisburg, Pa. 17125; when ordering, specify Map 39.

GEOLOGY OF THE OIL CITY AREA

"Geology and Mineral Resources of the Oil City [7 1/2-minute] Quadrangle, Venango County, Pennsylvania," by cooperating geologists Drs. Albert N. Ward (Slippery Rock State College), Michael T. Lukert (Edinboro State College), and William F. Chapman (Slippery Rock State College) has been published by the Pennsylvania Geological Survey.

This atlas combines detailed, full-colored maps of the bedrock (1:24,000) and glacial deposits (1:63,360) with text on one plate for convenient use. The three-column explanation provides information on the geology and environmental characteristics (ground-water and engineering characteristics and mineral resources) of the mapped units.

This new atlas provides a basic geologic inventory useful for land-use planning, ground-water and waste-disposal management, and mineral-resource development. It will benefit local officials, planners, industry, conservationists, and residents of the Oil City area.

Atlas 33a, "Geology and Mineral Resources of the Oil City Quadrangle, Venango County, Pennsylvania," is available for $5.10 (plus 6% sales tax for Pennsylvania residents) from the State Book Store, P.O. Box 1365, Harrisburg, PA 17125.

Groundwater Hydrology and Water-Resources Planning

The U.S. Water Resources Council has released a revision of "Essentials of Ground-Water Hydrology Pertinent to Water-Resources Planning." This is Bulletin 16 of the Council's Hydrology Committee. The publication is intended to help bridge the gap between groundwater hydrology and water resources planning.

Groundwater is an integral part of the nation's water resources. In fact, groundwater is often more readily available, less costly and of higher quality than surface water. Groundwater sources have been developed to supply about 20 percent of water withdrawn for use in the United States. In nearly all parts of the country as well as Pennsylvania, moderate to large amounts of groundwater are available for water supply at reasonable costs.

This bulletin presents the essential aspects of groundwater hydrology pertinent to water resources planning and discusses advances in analysis of groundwater systems and the factors influencing the management and administration of the groundwater resource. This report will be useful to those unfamiliar with groundwater analysis, utilization, or management because it introduces the principles and interrelationships that must be considered in the management and protection of the resource. It also will be useful to experienced hydrologists and areawide planners as an aid to integrating groundwater into comprehensive planning.

Copies are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. The stock number is 052-045-00083-5, and the price is $2.50.

Drought Conditions Continue In Pennsylvania

Below normal water conditions persist in the eastern half of Pennsylvania. January's streamflow was below the median range at all five eastern index stations as reported by the U.S. Geological Survey in its January issue of "Monthly Water Resources Summary for Pennsylvania." This is the seventh consecutive month in which streamflow has been below normal, causing moderate to severe shortages in some communities.

The map on our back cover shows the generalized pattern of groundwater for January based on index wells. Groundwater levels continued to decline seasonally but were below normal for the eastern half of the State. Groundwater levels refer to conditions near the end of the month. Water level in each observation well is compared with the average level for the end of the month determined from the past record for that well.

The report "Monthly Water Resources Summary for Pennsylvania" is usually published bi-monthly; however, it will be published monthly until drought conditions are improved. Issues of the summary are free upon application to the U.S. Geological Survey, Water Resources Division, P.O. Box 1107, Harrisburg, PA 17108.

The Lehigh Valley Gem and Mineral Show will be held Saturday and Sunday, March 14 and 15, 10 A.M. - 6 P.M. at the U.S. Marine Training Center, Pembroke Rd., Bethlehem, Pa.

MEET THE STAFF...

Robert C. Smith II, Chief
Division of Mineral Resources

Dr. Robert C. Smith, II, for the past 9 years an economic geologist and geochemist in the Bureau's Mineral Resource Division, has been promoted to Chief of that Division, following the recent retirement of Bernard J. O'Neill. Together with mineralogist John H. Barnes and other staff, Bob Smith plans to continue the Division's long standing policy of serving the needs of the mineral industry, fellow state agencies, and the general public. This will continue to be accomplished by obtaining and making available data on the location and distribution of metallic and non-metallic mineral deposits in the Commonwealth. Such data will continue to be made available through published reports, open files, and individual responses for assistance.

In addition to helping sustain Pennsylvania's mineral industry, Bob plans to continue using his geochemical and mineralogic background to serve the general public, mineral collectors, academic institutions, and other governmental agencies. Bob's experience in laboratory analyses will enable him to respond to requests for technical assistance from the Survey's other divisions as well.

Bob's past studies for the Bureau have dealt with zinc and lead, red-bed copper-uranium, asbestos, and mineral collecting in the Commonwealth. Presently, he is studying the distribution of natural radiation anomalies in granitic gneisses with J. H. Barnes. Data on newly found minerals in Pennsylvania are an additional interest. Of special interest to him are metallic minerals and those of rare elements.

Bob Smith is a graduate of Lafayette College and Penn State University where he had conducted comprehensive research on allanite and diabase, respectively. His non-professional activities are predominantly related to his family and church. At home, 25 different fruit trees provide much fun for him and his young daughters, Mandy and Jenny, and more than enough canning work for his wife, Gloria.

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GROUND WATER DIVISION

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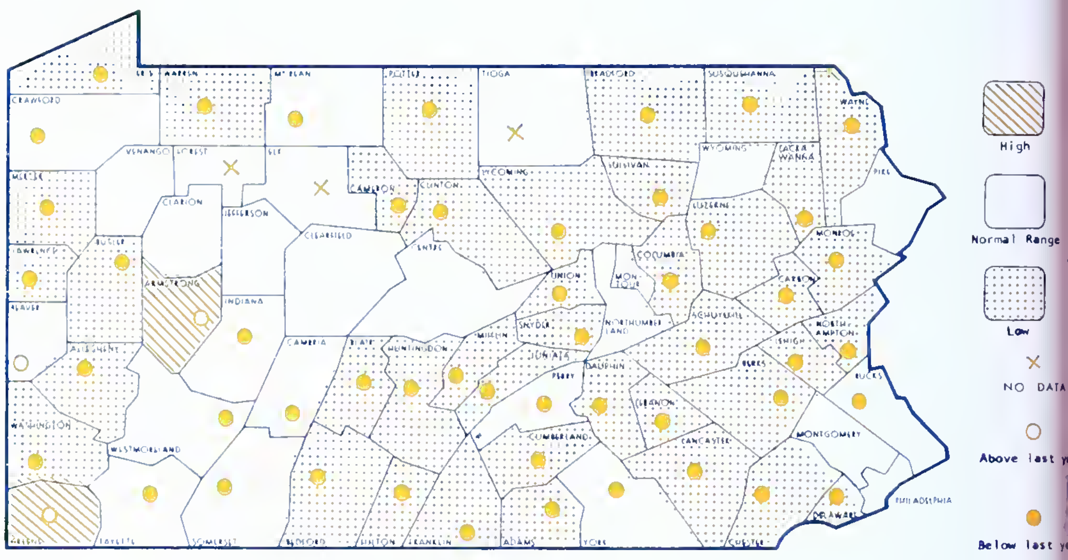
GROUND-WATER LEVELS
FOR
JANUARY 1981



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PENNSYLVANIA GEOLOGY

THE PENNSYLVANIA GEOLOGICAL SURVEY

COMMONWEALTH OF PENNSYLVANIA
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DEPARTMENT OF ENVIRONMENTAL RESOURCES
Clifford L. Jones, Secretary
OFFICE OF RESOURCES MANAGEMENT
Peter S. Duncan, Deputy Secretary
TOPOGRAPHIC AND GEOLOGICAL SURVEY
Arthur A. Socolow, State Geologist

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ON THE COVER: Pole Steeple in the Montalto gray quartzite member of the lower Cambrian (570 million years old) Harpers Formation is an outstanding promontory above Laurel Lake at Pine Grove Furnace State Park, southern Cumberland County. The cliff rises over 100 feet from its talus slope and stands more than 500 feet above nearby Mountain Creek Valley and Laurel Lake. Photo courtesy of J. P. Wilshusen.

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Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

Articles may be reprinted from this magazine if credit is given to the Topographic and Geologic Survey.

APRIL 1981

FROM THE DESK OF THE STATE GEOLOGIST

ACTIVITIES OF THE STATE GEOLOGIC SURVEY— A CONTINUING STORY

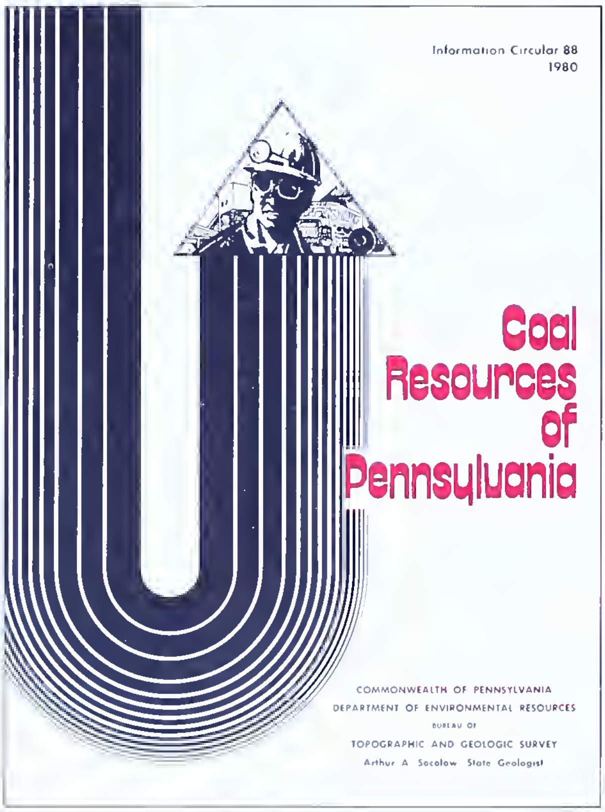
Even as we face a steadily increasing demand for geologic information amongst a wide and diverse array of users, I find that there are still some who are not aware that a state geological survey deals with applications of geology, and not just the mapping and identification of rock formations. Others apparently do not even know the meaning of geology.

Among the 18,867 incoming letters which we serviced in 1980, there were some on matters of geneology, gerontology, geodesy, meteorology, and metrology which we forwarded to more appropriate offices.

On the matter of the variety of applications of geology which our Bureau is involved with, it may best be demonstrated by enumerating just a few of our recent activities: 1) Designating favorable water well sites for critically deficient public water suppliers, utilizing our air photos and geologic maps. 2) Identifying favorable sand and gravel sites for a regional planning commission concerned with development and road building potential. 3) Evaluating geologic hazards and mineral lands along a proposed new high speed rail route. 4) Lab checking for asbestos content in construction aggregates. 5) Evaluating geologically safest and most economical routes for cross state utility lines. 6) Identify skid resistent construction stone for state and industry officials. 7) Advising a municipality on potential geologic problems along proposed sewer routing and sewage treatment sites. 8) Assessing geologic feasibility of proposed underground pump storage electric generating facility. 9) Assisting Civil Defence units with earthquake hazard planning and floodplain area maps. 10) Advising western Pennsylvania municipalities on means of mitigating damaging landslide sites. 11) Identifying engineering geology conditions under dams being checked for safety. 12) Helping to minimize coal mine roof falls by identifying geologic factors which will help to design safe mine construction. 13) Locating reliable groundwater sources for state hospitals and highway rest stops. 14) Identifying favorable waste disposal sites for local and regional needs.

These are only a sampling; the list could go on and on. Every department in the state, all levels of local government, large industries and small businesses, private citizens of all ages and all walks of life, all these are our geologic "customers." Such activities represent an essential function of a state geologic survey.

Arthur A. Socolow



COAL RESOURCES OF PA

The Pennsylvania Geological Survey's new Information Circular 88, *Coal Resources of Pennsylvania* is the result of a success story. The short text, concise tables, and colored maps were originally prepared as a supporting document for last years Governor's Coal Conference. It made such a hit among the conference attendees and their associates that we twice had to reprint it as a conference document.

Recognizing that the well organized, compact data on coal reserves, coal quality, and location of our coal resources is exactly what is needed by all who are interested in encouraging Pennsylvania's coal development, the Pennsylvania Geological Survey has now issued this information as Information Circular 88. This illustrated, 49-page publication is available from the State Book Store, P.O. Box 1365, Harrisburg, PA 17125 for $1.65 (plus 10 cents sales tax for Pennsylvania residents).

CORRECTION: In the February, 1981 issue of Pennsylvania Geology, Progress Report 193, "Oil and Gas Developments in Pennsylvania in 1979" was listed as costing $1.50 plus sales tax for Pa. residents. The actual cost of this report is $1.80 plus tax. We regret the error and hope you haven't had your order returned from the State Book Store for additional funds.

1980-81 DROUGHT

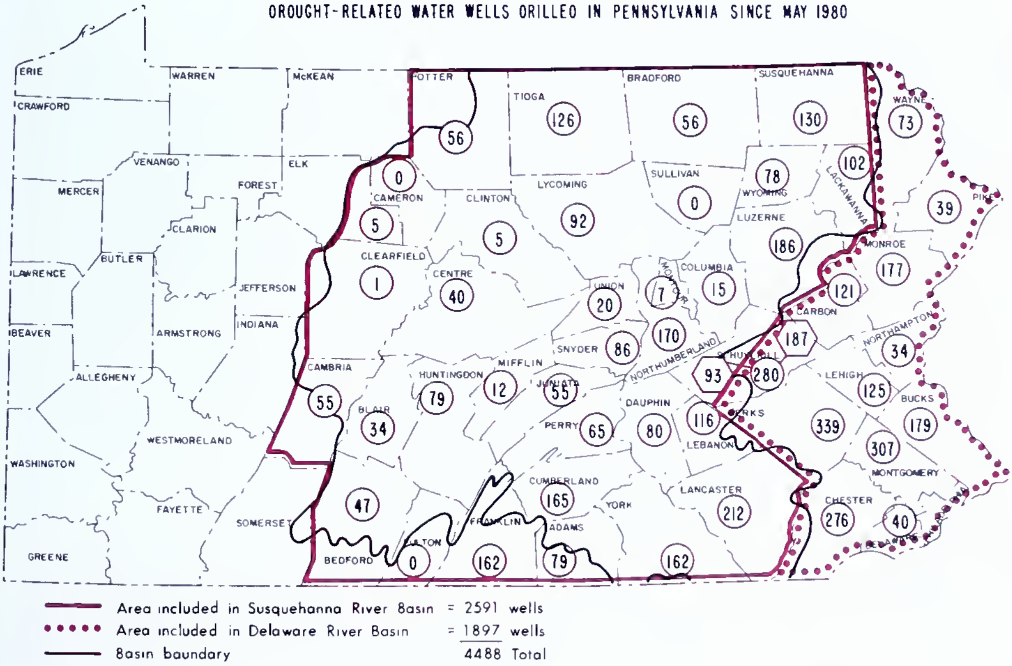
MEANS ADDITIONAL WELLS AND DEEPER DRILLING

The Bureau of Topographic and Geologic Survey recently completed a compilation of the number of drought-related, private water wells drilled or deepened in Pennsylvania since May of 1980.

The Survey's Environmental Geology Division staff canvassed 251 water well drillers in 47 drought-affected counties of the Susquehanna and Delaware River Basins in Pennsylvania. The water well drillers reported drilling 4488 drought-related water wells in Pennsylvania during the period May 1980 to mid-February 1981. They also reported that there now exists a backlog of drought-related water wells to be drilled or deepened and in January and February this demand sharply increased.

The results were incorporated with data compiled by other Department of Environmental Resources' bureaus on drought-related water problems in Pennsylvania, and submitted to the Governor's

DROUGHT-RELATED WATER WELLS DRILLED IN PENNSYLVANIA SINCE MAY 1980



Office. This information was used in support of Pennsylvania's request to the Federal Small Business Administration for official disaster designation of the drought-affected areas in Pennsylvania. If granted, businesses, citizens, and communities, who are experiencing drought-related water supply problems, may be eligible for economic assistance to restore damaged supplies or to develop a replacement water supply.

The need for economic assistance was reaffirmed during the canvassing of the water well drillers and by the direct communication of many communities in Pennsylvania now affected by the drought.

The Bureau was pleased to participate in a project that may result in direct benefit to the Commonwealth's businesses, citizens and communities. On behalf of the Department of Environmental Resources, we wish to extend thanks to the water well drillers for their cooperation and timely response.

Donna M. Snyder
Environmental Geology Division

METRIC TOPOGRAPHIC MAPS

The Defense Mapping Agency has developed a new series of 1:50,000-scale metric, 15-minute quadrangle maps for selected areas of the United States. Three quadrangles in Pennsylvania are currently available in this new map format. Harrisburg, dated 1977; New Bloomfield, dated 1974; and Orbisonia, dated 1976. The maps are compiled from U.S.G.S. 7 1/2-minute topographic maps with updated information. The map elements shown in metric units are contours, elevations and distances, and the Universal Transverse Mercator (UTM) Grid. The contour intervals used are either 10 or 20 meters. Elevations are shown in meters, and distances are shown in kilometers. A conversion graph is included in the marginal information on each sheet. The full-line UTM grid is shown in meters. The UTM grid system is a military grid system based on the transverse Mercator projection which consists of 60 north-south zones, each 6° wide in longitude.

The maps are available from the U.S.G.S., Branch of Distribution, 1200 South Eads Street, Arlington, Virginia 22202 for $1.25 each. Additional quadrangles will be issued in the future. These will be announced in "New Publications of the U.S. Geological Survey" which they publish monthly and in "Pennsylvania Geology."

THE TIPTON BLOCK - AN UNUSUAL STRUCTURE IN THE APPALACHIANS

by Rodger T. Faill

The Tipton block is a triangular-shaped downdropped fault block which occurs in northwest Blair County, Pennsylvania. The apex of the block points northwest and the opposite side forms part of the Allegheny Front. Topographically, the block is depressed at least 300 feet, with steep escarpments rising above the northern and western sides. Geologically, it is bounded on these two sides by faults (Fig. 1) and is depressed so that Alleghenian coals exist now in its southern part 1500 feet below their projection from the west.

The internal structure of the block is not simple. The southern quarter, separated by a fault from the rest, is itself faulted, and is structurally lower than the rest of the block. The remainder of the block is traversed through the center by a northeast-southwest trending syncline (Fig. 2) and by an anticline at the northwestern point. These faults and folds are terminated, or offset, by the bounding faults of the Tipton block and thus they represent independent deformation within the block.

Structures atypical of the Allegheny Front occur outside the block as well. Usually, the Plateau structure contours parallel the front; here, they bulge northwestward around the Tipton block (Fig. 2). This indicates that the Plateau rocks adjacent to the block have been elevated relative to a "normal" Plateau position. In addition, the area north of the Tipton block is extensively faulted (Fig. 2) and no where else along the front is there such a concentration of faults. The faults trend generally northwest-southeast, and their slickensides indicate horizontal movement. Thus this area was a "pocket" of strike slip faulting.

The Tipton block, its internal structure, and the adjacent structures is a singular complex along an otherwise simple structural front. The cause for this structural concentration can be found by examining its position within the regional structure.

The Allegheny structural front extends in a broad arc, convex northwestward, from Williamsport in Lycoming County southwestward past Tyrone and Altoona in Blair County to Somerset County and then into western Maryland. The Valley and Ridge Province, composed of large amplitude folds and numerous faults, is to the southeast; the Allegheny Plateau, composed of low amplitude folds and few faults, is to the northwest.

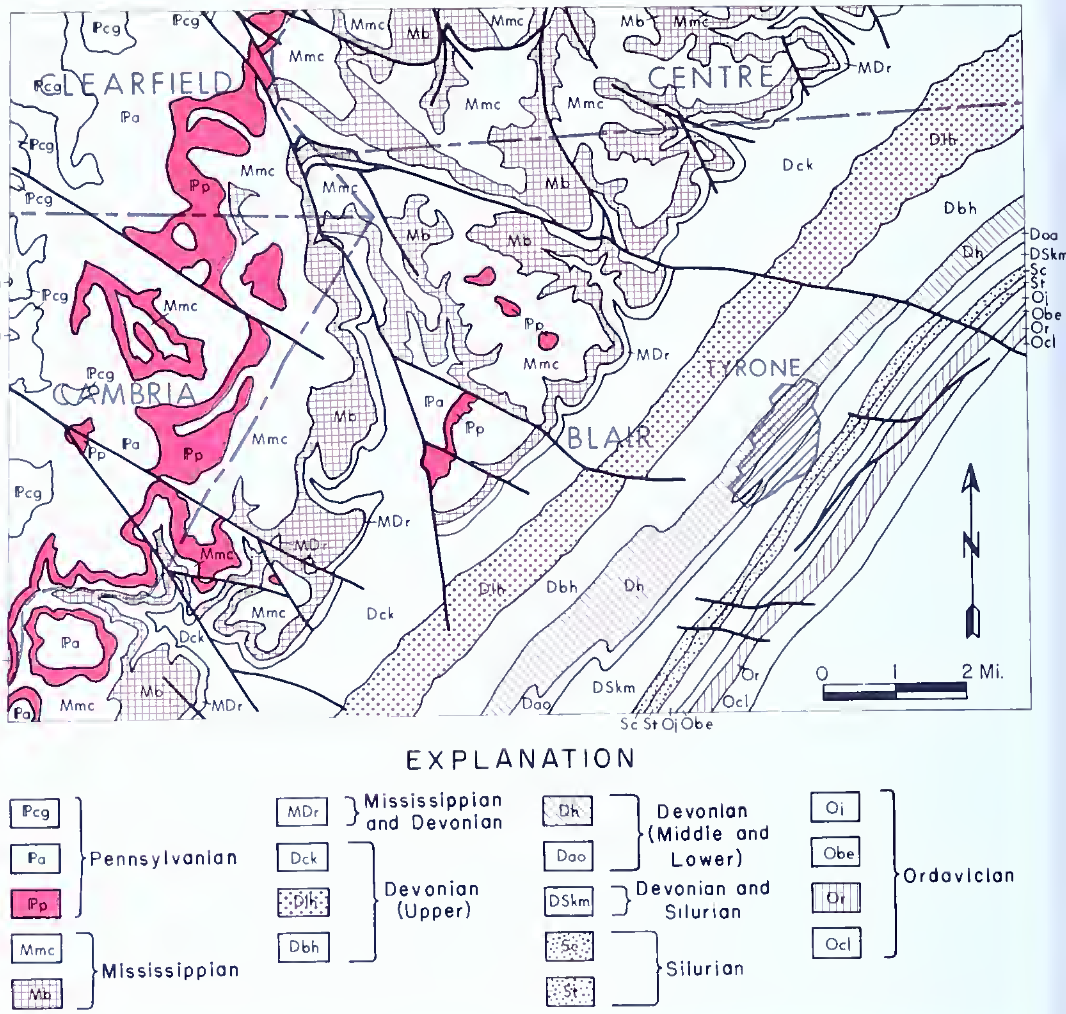


Figure 1. Geologic map of the Tipton block area. The northern bounding fault exceeds eastsoutheastward north of Tyrone, across the Devonian and Silurian and into the Ordovician carbonate formations of Nittany Valley. The western bounding fault terminates in the Devonian rocks to the south, and extends past the Tipton block apex into the Pennsylvanian coal measures. A geometrically similar block, but with much less vertical displacement, exists to the southwest, and an even smaller one is to the northeast.

In both provinces, the Paleozoic rocks have moved northwestward on a deep, regional, bed-parallel fault (decollement) (Fig. 3). This motion was impeded by splay faults branching upward from the decollement, above which folds developed. Thus the northwestward movement on the decollement was converted into deformation (folding and faulting) of the moving Paleozoic rocks. In the Valley and Ridge province, the decollement is located at the top of the

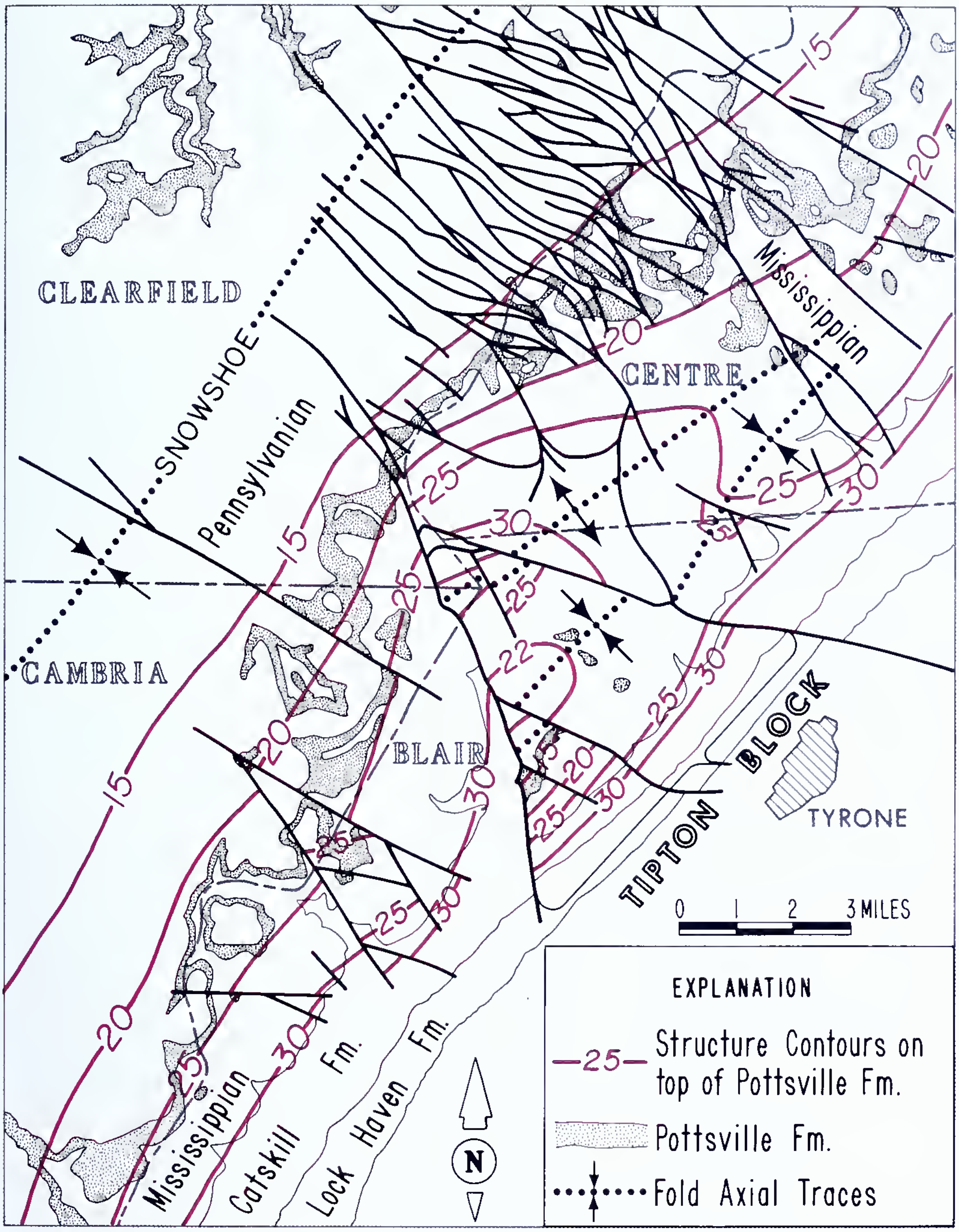


Figure 2. Structure contour map of the Tipton block area, with contours drawn on the top of the Pottsville Formation. Along much of the length of the Allegheny Front (here, approximately at the Catskill-Mississippian boundary), the Plateau rocks dip gently from the Front to a synclinal hinge (here, the Snowshoe syncline). In the Tipton vicinity, the structures are extensively cut by faults, and deflected northwestward around the Tipton block.

Lower Cambrian rocks; in the Allegheny Plateau province, in the Upper Silurian rocks. The boundary between the two provinces, the Allegheny structural front, is where the decollement ramps upward from the Cambrian to the Silurian rocks. As a consequence of smaller decollement movement in the Plateau than in the Valley and Ridge, the Plateau folds have much smaller amplitudes.

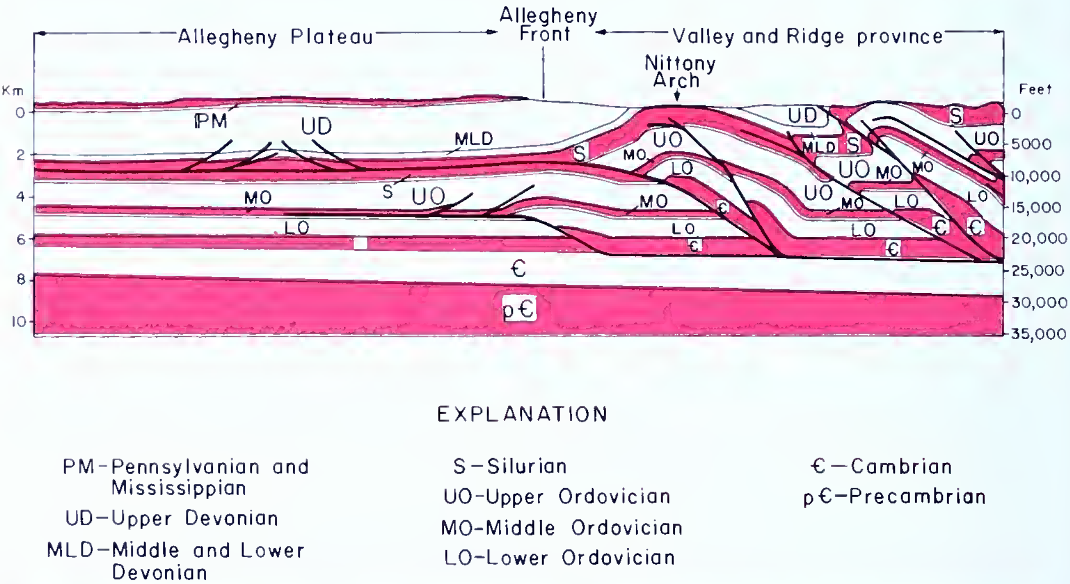


Figure 3. Generalized cross-section of the Allegheny Front, the boundary between the Valley and Ridge, and the Plateau provinces. The fundamental element is the decollement (bed-parallel fault) on which the Paleozoic rocks moved to the northwest. Splays from the decollement lifted the rocks, creating anticlines in the overlying formations. In the Valley and Ridge province, the decollement is in Cambrian rocks, displacement on the splays was large and thus the fold amplitudes are large. In the Allegheny Plateau province, the decollement lies in the Silurian rocks, the splays had small displacement, and thus the folds have only low amplitudes.

The Allegheny structural front comprises two relatively linear segments, with an intervening bend at Tyrone and another bend at its eastern terminus at Williamsport. This latter bend is a consequence of the eastward plunge and diminution of the Nittany Arch, the northwesternmost major anticline in the Valley and Ridge province. The Tipton block sits athwart the first, the intervening bend.

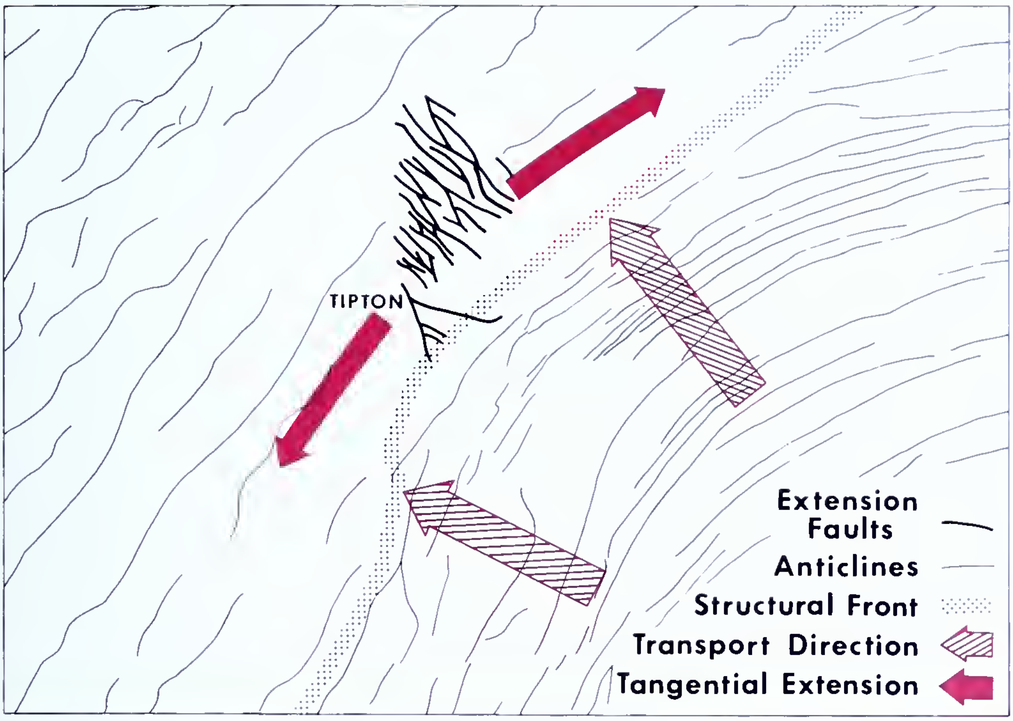


Figure 4. The divergent northwestward movements in the Valley and Ridge province created a zone of northeast-southwest extension, leading to the development of the "pocket" of strike-slip faulting, and of the Tipton block.

Throughout the Valley and Ridge province, slicklines on faults and bedding surfaces indicate that horizontal movement was perpendicular to the fold trends. Hence, the two linear segments of the front moved in divergent directions, creating an area of extension (stretching) (Fig. 4). The strike-slip faults north and southeast of the Tipton block are direct manifestations of this northeast-southwest extension, as reflected by the NW-SE trending strike-slip faults north of the block. Under this reduced stress condition, the triangular shaped Tipton block formed and moved northwestward a greater distance than the adjacent areas. In the process of movement, the block slid partly underneath the adjacent rocks, elevating them, and itself becoming folded in the process. It is not clear what mechanism was acting at depth.

Thus the Tipton block stands as a singular structure in the Appalachians in central Pennsylvania, developed by the divergence of two larger portions of the Valley and Ridge Province.

THE PENNSYLVANIA GEOLOGICAL SURVEY ASSISTS PUBLIC WATER SUPPLIERS

Eight months of drought conditions during 1980 and 1981 produced below normal water-level conditions in the eastern half of Pennsylvania. This continuous streamflow shortage and below normal groundwater levels caused moderate to severe public water supply problems in many eastern Pennsylvania communities. Groundwater levels during the summer and winter months are seasonally lower, but during this drought period they fell below their seasonal normals.

The number of public water supply companies affected by the drought grew steadily from September 1980 to February 1981. By mid-February, 85 companies supplying 440,000 people were experiencing extreme shortages. Rainfall from mid-February to present has helped, but the water supply problems will not be over until recharge to the groundwater brings the water table back to near "normal levels" throughout the 47 counties affected.

During this emergency period of serious public water supply problems, Survey geologists were asked and quickly responded to requests for assistance. In most cases this assistance involved a hydrogeologic study of the immediate area, selection of the most promising aquifer(s) available to the community, and special techniques to identify the best site or sites for new public water supply wells.

The following list includes some of the communities assisted by the Pennsylvania Geological Survey:

- Adams County
  - Cashtown Borough
- Berks County
  - Oley Township
  - Womelsdorf Borough
  - Robesonia Borough
- Bradford County
  - Troy Borough
- Carbon County
  - Bowmanstown Borough
  - Summit Hill Borough
- Dauphin County
  - Millersburg Borough
- Franklin County
  - Washington Township
- Lancaster County
  - Strasburg Borough
  - Akron Borough
- Lebanon County
  - City of Lebanon
  - Richland Borough

Lehigh County
East Bangor Borough
Lycoming County
Williamsport Hospital
Perry County
Duncannon Borough
Schuylkill County
Schuylkill County Municipal Authority
Schuylkillhaven Borough

The Bureau of Topographic and Geologic Survey is pleased that its long-established groundwater data base and its staff of hydrogeologists enabled a prompt response to the emergency needs of these communities.

PALEOECOLOGY OF FENESTRATE BRYOZOANS IN THE WYMPS GAP LIMESTONE OF SOUTHWESTERN PENNSYLVANIA

by August H. Simonsen
Pennsylvania State University
McKeesport, PA

Late Paleozoic strata underlying southwestern Pennsylvania yield many fossils useful in interpreting the ancient environments in which those rocks were deposited. One major group, the phylum Bryozoa, has been virtually unstudied in the region, but is quite abundant in places. Elsewhere in North America, the delicate fronds of fenestrate-type bryozoans have been noted as excellent paleoecologic indicators, biostratigraphic guides, and sedimentologic contributors. Recent recognition of the abundance of fenestrate bryozoans near Uniontown, Pennsylvania stimulates interest in the details of their occurrence, especially for paloenvironmental implications.

The abundant fenestrate bryozoans occur in the non-working Thompson Quarry, 100 yards north of Route 40 about seven miles east of Uniontown, Pennsylvania, and one mile west of Chalk Hill, Pennsylvania. The Wymps Gap Limestone is about 20 to 30 feet thick at this outcrop. It is the thin, marine limestone in the lower Mauch Chunk Formation (Mississippian System). Formerly, it was referred to as the Greenbrier Limestone of Pennsylvania (Flint, 1965). The Wymps Gap Limestone is a thin tongue extending from the much thicker Greenbrier Formation of West Virginia into the

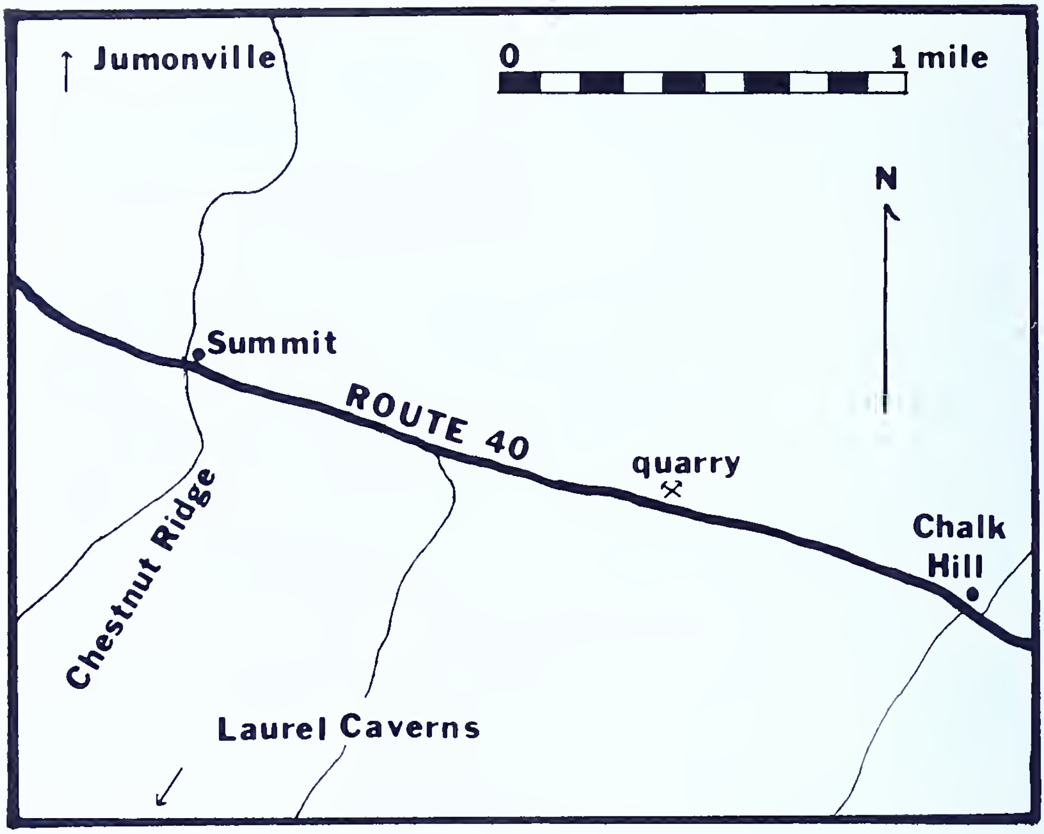


Figure 1. Location Map of the Thompson Quarry Outcrop of the Wymps Gap Limestone

deltaic, clastic beds of the Mauch Chunk Formation representing the transgression of a sea in the MIssissippian Period.

Outcrops of the Wymps Gap Limestone can be found in Fayette and Somerset counties, especially in the Chestnut Ridge and Negro Mountain areas. The site of the type locality is at Wymps Gap, twelve miles south of Uniontown, Pennsylvania. A massive, dark, fossiliferous limestone is overlain by interbedded limestone and calcareous shale. Near Wymps Gap, the limestone has several outcrops which show thicknesses of thirty to forty feet (Hickok and Moyer, 1940). In Westmoreland County the Wymps Gap Limestone pinches out near Latrobe, Pennsylvania.

Several fossil groups are found in the assemblage of the Wymps Gap Limestone, including many species of brachiopods, pelecypods, a cephalopod, a gastropod, a blastoid, crinoids, a solitary coral, a trilobite, and several bryozoans.

Fenestrate bryozoans consist of a hardened colony (i.e. zoarium), in which the polyp-like, individual zooids had lived. The zoarium

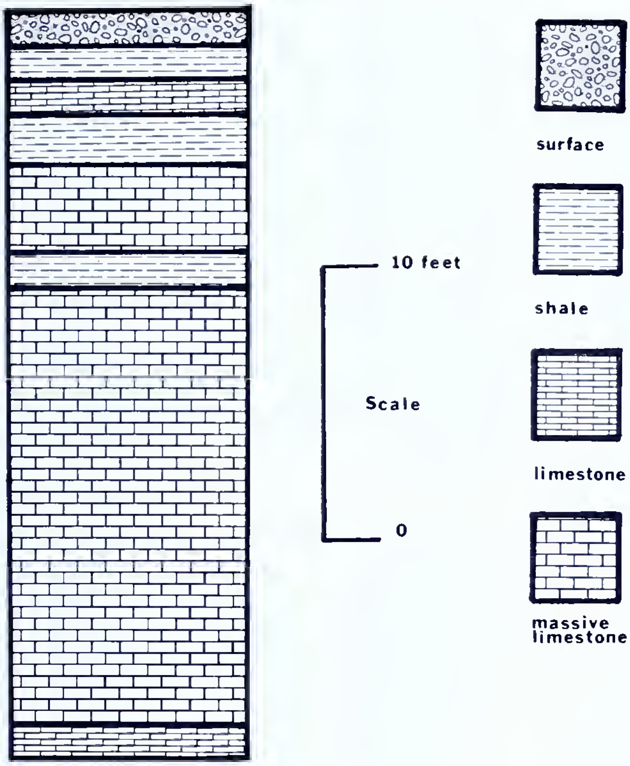


Figure 2. Generalized Stratigraphic Column of the Wymps Gap Limestone at. the Thompson Quarry near Chalk Hill, Pennsylvania.

appears as a trellis- like perforated sheet (i.e. fenestrate), composed of branches and crossbars (i.e. dissepiments). The zooecium is the non-living skeleton of the zooid which expresses itself on the frontal side with an aperture. Three genera of fenestrate bryozoans have been identified, *Fenestella*, *Polypora*, and *Septopora*; studies in progress will attempt to further identify these forms to species level.

Fenestella has a very delicate zoarium which is fan-like. The zooecia are arranged in two rows along each branch, with none on the dissepiments. There are three to four zooecia between successive dissepiments in each row. The two rows are separated by a thin, low, straight ridge (i.e. carina) on the frontal side of each branch with nodes or spines at intervals. The largest zoarium found measured 35 mm in length and 16 mm in width at the distal end.

Polypora has a robust, fenestrate zoarium with three or four rows of zooecia on each branch but none on the dissepiments. Between the rows of zooecia, there are low carinas. All of the zoaria found were small broken fragments of larger fronds.

Septopora is medium-sized having a fenestrate zoarium with two rows of zooecia on the branches and some zooecia on the dissepiments. Several nodes appear on the branches. All of the zooaria were broken.

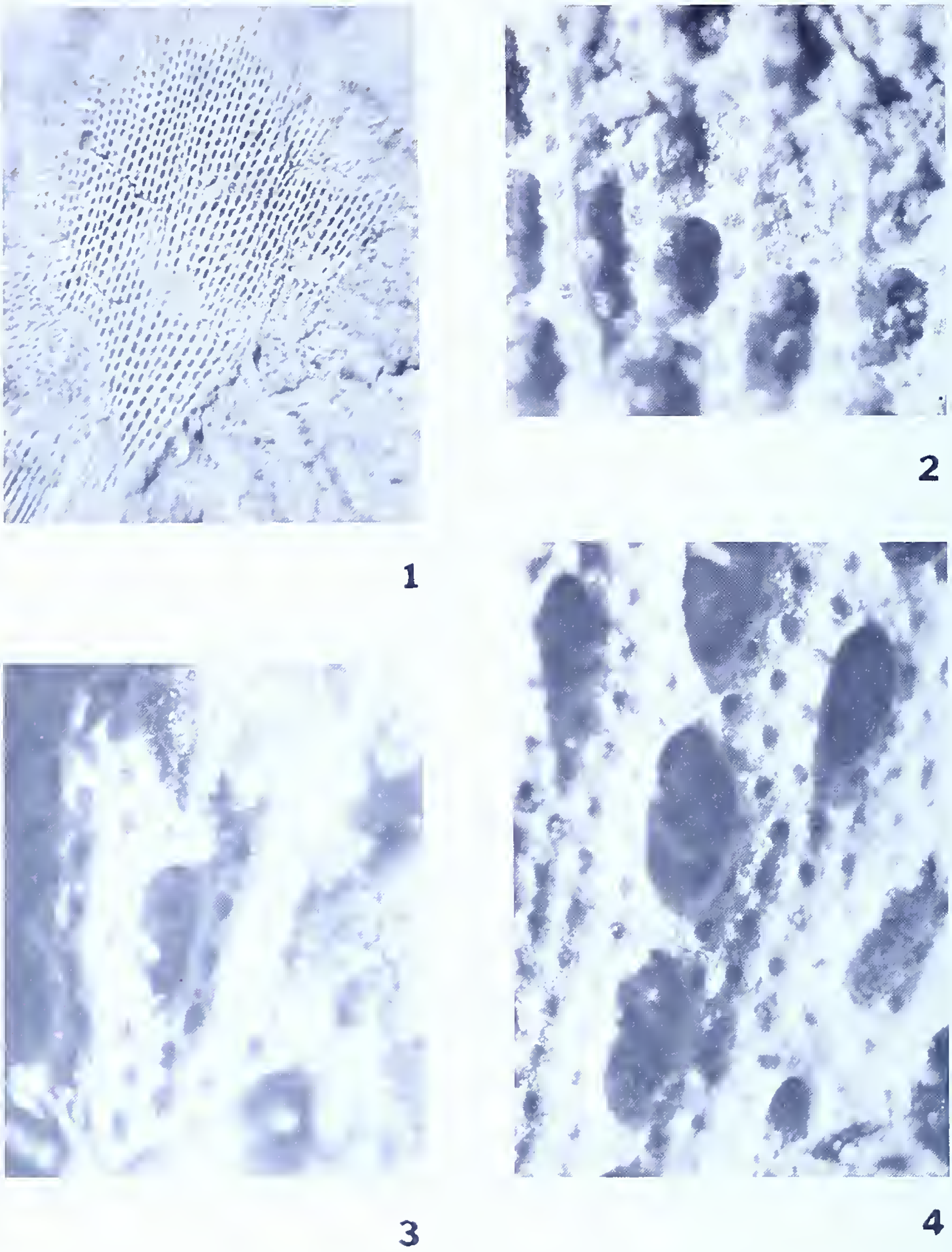


PLATE 1

(1) Large frond of *Fenestella*, 2X

(2) Frontal view of *Fenestella* showing zooecial apertures, branches and dissepiments, 25X

(3) Frontal view of *Septopora* showing zooecial apertures, branches and dissepiments, 25X

(4) Frontal view of *Polypora* showing zooecial apertures, branches and dissepiments, 25X

Most of the fenestrate bryozoans collected in the Wymps Gap Limestone were found in the shale and lower massive limestone lithofacies (see Figure 2). Many brachipod species were found in the assemblages containing the fenestrate bryozoans. The large percentage of calcareous matter and the apparent lack of sand-sized particles suggests that the fenestrates inhabited an offshore, normal-marine, shallow environment. The water was deep enough to be below wave base and, therefore, was relatively quiet; possible depth might have been 50 feet or more, in comparison with similar units studied elsewhere. The fenestrate bryozoans were bottom dwellers (i.e. sessile benthonic) and filtered the water that passed by them in order to capture their microscopic prey. The preferred bottoms were limy, mud bottoms as revealed by the various lithofacies.

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WINFIELD OPEN HOUSE

W. O. Faylor, Jr., President of Faylor-Middlecreek, Inc., has announced that mineral club members may visit the Winfield Quarry on May 16th and September 19th between 8:00 AM and 4:00 PM. Food may be purchased at a stand in the parking lot.

Visiting vehicles are never allowed in the quarry and there is a steep climb into and out of the quarry. Hence, no one should enter the quarry unless they are in good enough physical condition to walk out on their own.

Participating clubs should notify Faylor-Middlecreek, Inc., P.O. Box 117, Winfield, PA 17889 in advance. A donation of $1.00 per guest will be used to defray safety personnel costs. Hard hats, safety shoes, and safety glasses are required, and all other rules from the company's personnel must be followed.

Excellent specimens of calcite, sphalerite, and strontianite have been collected in recent years. Celestine, fluorite, and galena are also collectable at times. Additional information is available in the Pennsylvania Survey's General Geology Report 33, "Mineral Collecting in Pennsylvania," 1976 edition.

STATE GEOLOGIST ELECTED TO NATIONAL ASSOCIATION POST

State Geologist Arthur A. Socolow has been chosen to serve as Chairman-Elect of the 4500 member Geology and Geographic Section of the American Association for the Advancement of Science. Dr. Socolow has for many years been active in the affairs of this major national scientific organization which is dedicated to advancing the frontiers of science, as well as applying the results of scientific research to the needs of our society. Dr. Socolow has served not only as an officer, but also as technical manuscript evaluator for "Science," the official weekly journal of the association.

pennsylvania geopics

Rockfall in roadcut, south of Franklin, Pennsylvania. Rockfall here results from the intersection of two sets of rock fractures which are called joints. Rockfalls are a common occurrence where the rock is fractured and water enters the fracture and freezes. Photo by Jesse Craft

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GROUND WATER DIVISION

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GROUND-WATER LEVELS
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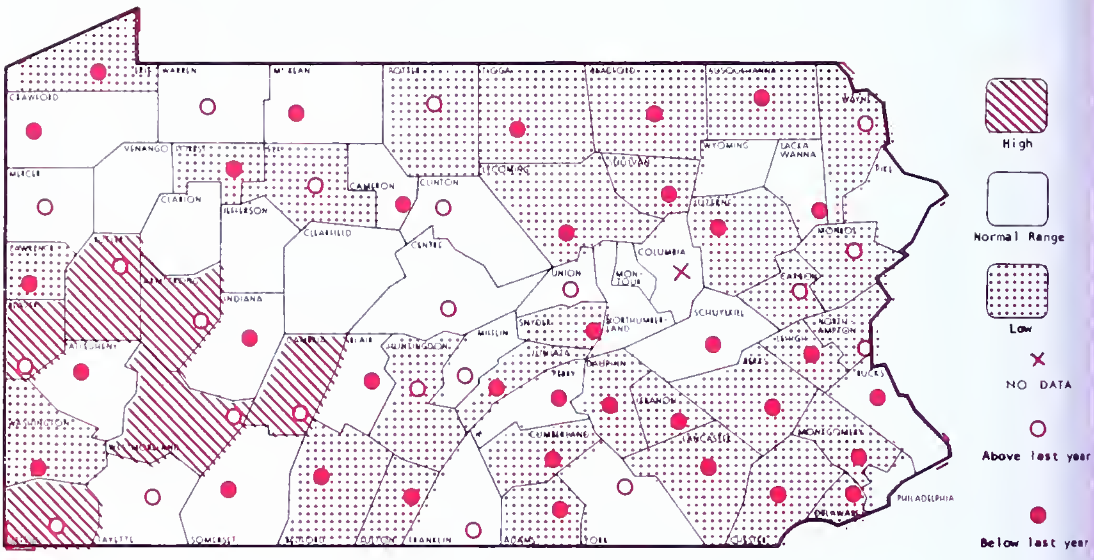
MARCH 1981



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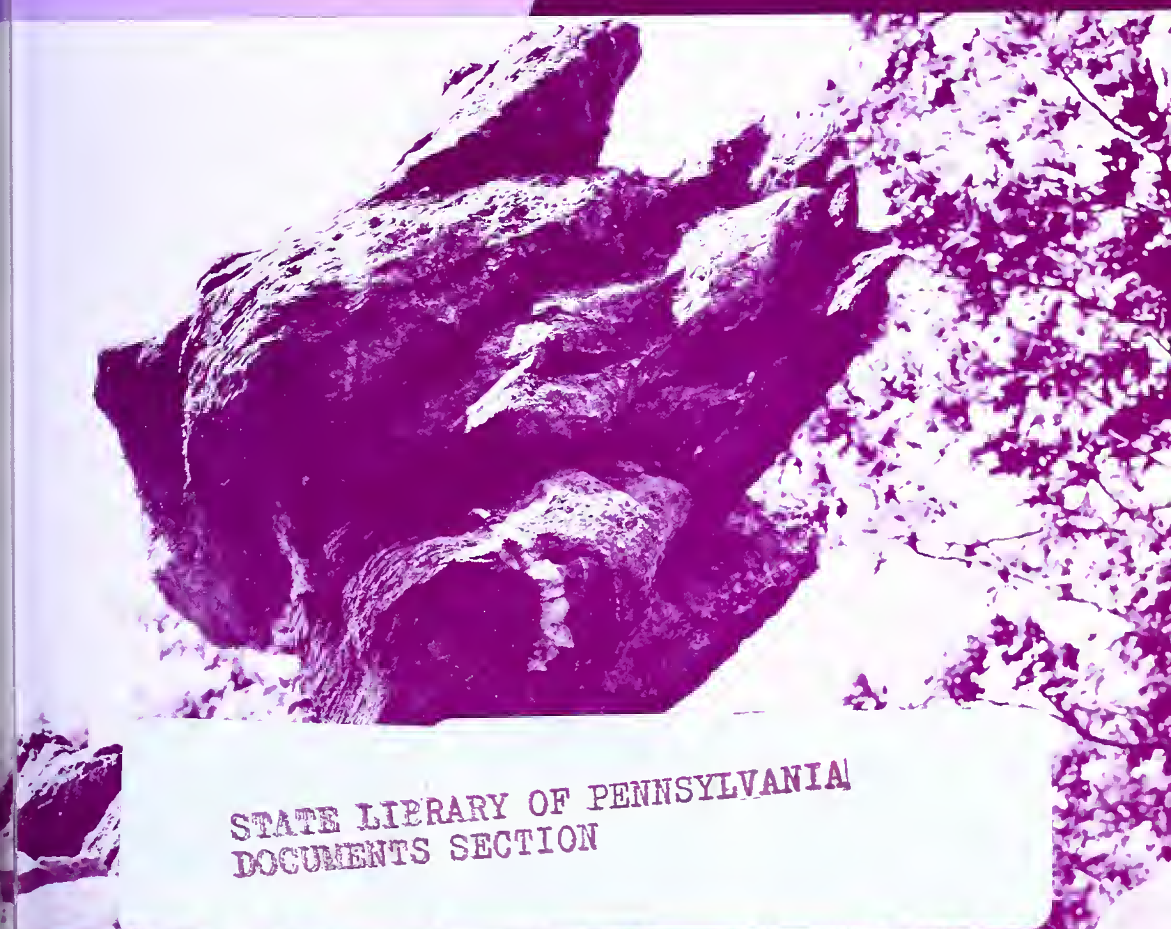

PENNSYLVANIA GEOLOGICAL SURVEY VOL. 12/3

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ON THE COVER: A balanced pinnacle about 15 feet high forms part of the crest of Sunset Rocks on Little Rocky Ridge 1 mile west of Pine Grove Furnace State Park, southern Cumberland County. This narrow, rocky spine is the Cambrian (570 million years old) Weverton Formation, a coarse-grained, light-gray, impure sandstone and quartzite. Note the quartz vein near base of pinnacle. Photo courtesy of J. P. Wilshusen.

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JUNE 1981

FROM THE DESK OF THE STATE GEOLOGIST

KEEPING UP WITH THE WORLD

I got into a somewhat heated discussion with a colleague recently over a certain new international development, and he asked me why I was so concerned over an affair outside the United States. I tried to explain that in large measure I became an economic geologist because of my fascination with the inter-relationship of minerals to world affairs, both present and past. Historically, one can document the sequence of world trade, colonization, tarrifs, embargoes, and numerous wars, all revolving around the need for, and varying accessibility to, the world's mineral resources. These forces still prevail, and they impact directly into Pennsylvania.

Most conspicuously, the OPEC stranglehold on oil and the mid-East political-military turmoil has stimulated Pennsylvanian oil and gas drilling, as well as expansion of our coal production. Conversely, the ready access to cheap, high grade iron ore in politically friendly foreign nations has lead to the closing of the Grace Mine at Morgantown, Pa., despite large remaining iron ore reserves. The less than happy relations between South Korea and neighboring mainland China has caused Korea to come shopping for coal in Pennsylvania, even while China's coal resources are astronomically high. A renewed national concern over our dependence on foreign sources for various industrially strategic minerals has resulted in inquiries and exploration interest in Pennsylvania for such minerals as chromite, manganese ore, mica, and even substitutes for bauxite, the largely foreign source of aluminum.

Foreign events may also have less direct, but nevertheless significant impacts on Pennsylvania. Governmental turmoil in Latin America, leading to "hot and cold" relationships with the U.S., affect the price and availability of essential copper, nitrates (fertilizer and chemical), tin, iron ore, and quartz crystals, not to mention coffee, bananas, and meat. Strikes, racial upheavals, and border clashes in Africa inevitably impact on Pennsylvania's economy as resources become less (or sometimes more) available.

Even the governmental actions of friendly Canada and the European Common Market affect us as those nations adopt policies of self sufficiency and limitations on foreign (U.S.) investments in their natural resources.

So when you see me reading the foreign affairs column of the *New York Times*, the *Washington Post*, or the *Wall Street Journal*, its not because I've lost interest in Pennsylvania—its because I'm trying to keep up with tomorrow's impact on Pennsylvania.

Arthur A. Socolow

Recovery of ground-water levels from drought conditions in two areas of the Susquehanna River Basin in Pennsylvania

By
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Precipitation in the fall of 1980 and early winter of 1981 was significantly below normal in parts of Pennsylvania and other mid-Atlantic states. Ground-water levels were consistently below their normal seasonal ranges and, during the winter, approached the record low water levels set during the drought of the early 1960's. As a result, many municipal and private domestic wells experienced significant reductions in yield and quality; some wells even went dry.

In the late winter and early spring of 1981, precipitation approached normal seasonal amounts. However, above-normal seasonal precipitation still is needed to replenish the ground-water system to its normal levels. Consequently, many ground-water supply systems are still marginal at best, with the possibility of an even relatively short period of below-normal precipitation causing supply problems again.

A prerequisite for improved utilization and managment of ground-water resources is a better understanding and quantification of the ground-water system, including a reliable method of assessing changing ground-water conditions during droughts. A possible method for "tracking" a drought is periodic measurement of ground-water levels in many wells. Two examples of this method were recently completed and the results are presented here.

The U.S. Geological Survey is involved in two ground-water resource evaluation studies in Pennsylvania in which periodic water-level measurements are being made. The Lower Susquehanna River Basin in Pennsylvania and Maryland is being studied in cooperation with the Susquehanna River Basin Commission, and Columbia County and adjacent areas are being studied in cooperation with both the Susquehanna River Basin Commission and the Pennsylvania Topographic and Geologic Survey (see Figure 1 for locations of these

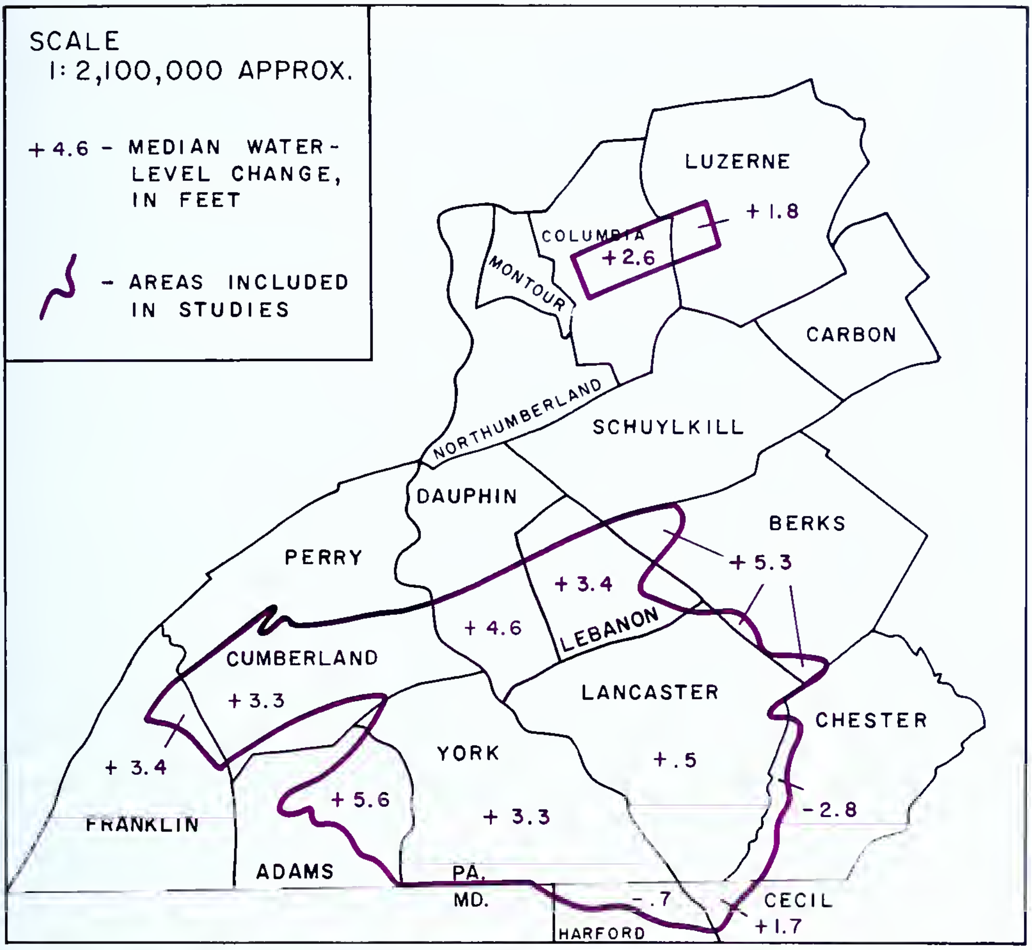

Figure 1. Median water-level changes, in feet, by county, for parts of counties in study areas.

areas). Both studies include the construction of numerical ground-water flow models to be used as tools to evaluate the ground-water resources. As part of the data needed for calibration of these models, seasonal water levels are being measured. So far, water levels have been measured twice in each study area. In the Lower Susquehanna River Basin study, water levels in 331 wells were measured on October 27-31, 1980 and April 20-24, 1981; in the Columbia County study, water levels in 81 wells were measured on December 22-23, 1980 and April 29-30, 1981. Although the initial measurement periods in each study do not coincide, both were during the period of below-normal precipitation and are assumed, for purposes of this discussion, to be representative of drought conditions. The latter measurement periods are representative of ground-water conditions shortly after precipitation had eased the worst drought conditions. The differences between the two water-level measurements in all wells are then estimates of the degree of recovery from drought conditions.

The water-level change data were grouped by county, physiographic province, and gross rock type and topographic setting of wells. Median values were computed for each grouping.

Figure 1 shows the median water-level change in each county during the previously mentioned time period. A positive median change indicates a rise in water level. Median and range of water-level changes for the county grouping are summarized in Table 1. All calculated statistics apply only to those parts of each county or province that are within the two study areas. Water-levels in Lancaster and Chester Counties in Pennsylvania and Harford and Cecil Counties in Maryland show the least recovery. In fact, Chester and Harford Counties show a decline in water levels.

Figure 2 shows the median water-level change in each physiographic province. Table 2 presents a summary of computed statistics for the physiographic province grouping. As with the county grouping, the southeasternmost physiographic provinces show the least recovery, with the Piedmont Upland Section actually showing a slight decline.

Results of both county and physiographic province groupings are probably indicators of regional precipitation patterns. But they do not account for local differences in rock type, topographic setting, and other variables that affect normal seasonal water-level

Table 1. Water-level changes, in feet, by county, in study areas, comparing October 1980 with April 1981*

County	Number of Wells	Median Range	Range of Change High	Range of Change Low
Adams	20	+5.6	+15.9	+ .9
Berks	6	+5.3	+10.4	+ 4.4
Cecil (Md.)	6	+1.7	+10.9	− 4.9
Chester	7	−2.8	+13.1	−14.6
Columbia*	62	+2.6	+17.6	− 2.4
Cumberland	37	+3.3	+28.1	− 5.2
Dauphin	15	+4.6	+11.8	−10.9
Franklin	6	+3.4	+ 4.9	− 1.7
Harford (Md.)	15	− .7	+10.0	− 4.8
Lancaster	103	+ .5	+23.4	−11.2
Lebanon	32	+3.4	+16.3	−11.7
Luzerne*	19	+1.8	+19.8	− 2.1
York	84	+3.3	+27.1	− 6.8

*Water levels in these counties were measured in December 1980 and April 1981.

change, as well as drought recovery. Therefore, the magnitude of the water-level changes given by the medians are not meaningful values by themselves; but they are apparently useful indices of relative recoveries on a regional scale.

The water-level change data were grouped by gross rock type and topographic setting to analyze variations due to these important factors (Table 3). The shales, interbedded shales and sandstones, and interbedded shales and carbonates show the greatest water-level rise of all the rock types. They also show progressively greater water-level rise from valley bottom to hilltop. Crystalline rocks show the opposite trend. Carbonates show no apparent relationship between topographic setting and water-level change. It is obvious that even at this somewhat more refined level of analysis, there are still some other unanalyzed factors that are important in determining the amount of water-level change in wells. Some other possible factors include thickness of overburden, depth to the water table, depth to water-bearing zones, degree of connection between ground-water and surface-water systems, soil type, land use, and local precipitation differences. Many of these factors are interdependent and their individual effects are difficult to separate from the total effect. To successfully analyze the water-level changes observed over a given time

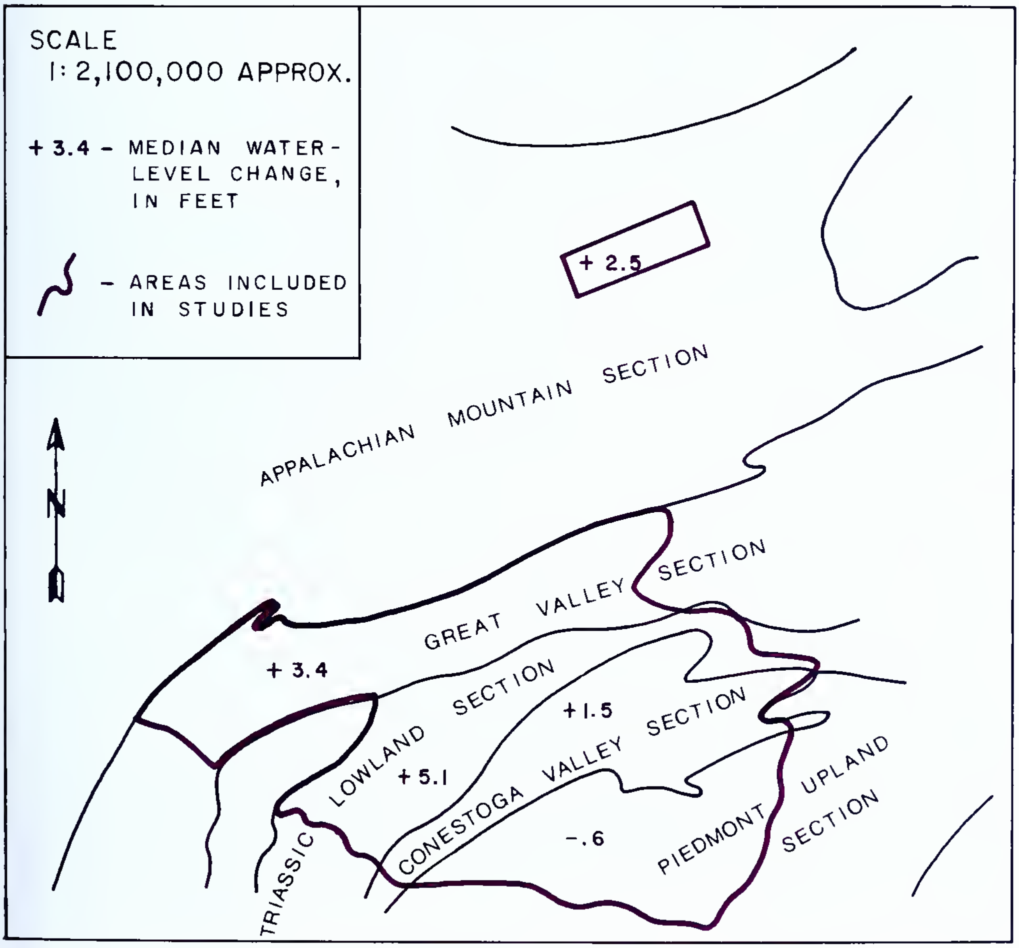

Figure 2. Median water-level changes, in feet, by physiographic province, for parts of provinces in study areas.

Table 2. Water-level changes, in feet, by physiographic province, in study areas comparing October 1980 with April 1981

Physiographic Province	Number of Wells	Median Range	Range of Change High	Range of Change Low
Appalachian Mountain* Section	81	+2.5	+19.8	– 2.4
Great Valley Section	82	+3.4	+28.1	–11.7
Triassic Lowland Section	74	+5.1	+21.9	–10.9
Conestoga Valley Section	92	+1.5	+15.3	–14.6
Piedmont Upland Section	83	– .6	+27.1	– 9.6

*Water levels in this section were measured in December 1980 and April 1981.

Table 3. Median water-level changes, in feet, by gross rock type and topography, for both study areas combined Number of wells is in parentheses.

Gross Rock Type	Valley Bottom	Lower Slope	Middle Slope	Upper Slope	Hilltop
Glacial outwash	+1.5 (10)	+ .7 (1)	--	--	--
Shale	+2.3 (15)	+2.6 (24)	+3.4 (32)	+3.7 (16)	+ 5.6 (17)
Carbonate	+1.9 (14)	+1.0 (17)	– .2 (32)	+2.0 (23)	+ 1.8 (10)
Interbedded shale and sandstone	+3.4 (4)	+3.2 (22)	+5.7 (27)	+6.4 (20)	+ 7.1 (8)
Interbedded shale and carbonate	+2.6 (6)	+1.6 (3)	+2.8 (1)	+6.3 (2)	+10.7 (2)
Crystalline	+2.7 (1)	+4.8 (15)	+ .7 (38)	–1.1 (35)	– 1.4 (17)

period, one must integrate all these factors and quantify their interactions.

These complications notwithstanding, periodic water-level measurements show some potential for regional assessment of changing ground-water conditions, especially in periods of extreme conditions such as droughts. As shown by this application of periodic water-level measurements, ground-water levels in parts of Pennsylvania and Maryland have not recovered equally well from the drought of the past fall and winter.

PENNSYLVANIA GIVES THE WORLD 3 NEW MINERALS

The recognition of a "new" mineral is a significant event in the mineralogical world. It indicates that here is a substance that has formed spontaneously and is existing in our world, and has never before been found and identified by anyone, anywhere in the world. Of course, the substance isn't really "new," it just hasn't been recognized before. Within the past several years, three substances from Pennsylvania have been recognized and verified by the Commission on New Minerals and Mineral Names of the International Mineralogical Association as "new" minerals. These substances are now known as the minerals desautelsite, downeyite, and matulaite.

Desautelsite ($Mg_6Mn_2^{3+}(CO_3)(OH)_{16}.4H_2O$) was first collected in San Benito County, California, by Thomas D. Palmer. However, the "type specimen" (that which was actually described and named) was collected by Martin Anné and Donald Schmerling of York County at the Cedar Hill quarry in Lancaster County. The mineral was described by Pete J. Dunn, Donald R. Peacor, and Thomas D. Palmer (1979) and was named for Paul E. Desautels, curator of the mineral and gem collections of National Museum of Natural History at the Smithsonian Institution. The mineral is bright orange and forms simple hexagonal crystals, sometimes imbedded in colorless brucite in association with altered serpentine. Desautelsite is chemically related to the mineral pyroaurite, which also occurs at Cedar Hill, but has trivalent manganese (Mn^{3+}) in place of the iron (Fe^{3+}) that is present in pyroaurite (Dunn and others, 1979).

Downeyite (SeO_2) was first collected near vents, from which gases from subsurface fires were escaping, on a burning culm bank near Glen Lyon, Luzerne County. It was described by Robert B. Finkelman and Mary E. Mrose (1977), who named it for its discoverer, Wayne F. Downey, Jr., of Malvern. Downeyite forms as acicular, prismatic, tetragonal crystals that are colorless and have adamantine luster. It forms in association with selenium, sulfur, mascagnite, and $NH_4Al(SO_4)_2$ at temperatures of about 200°C, and is a product of the escaping gases. It is an extremely hygroscopic material. When it is removed from the hot, dry conditions under which it forms, it begins to absorb water, which, in turn, dissolves it. Within a minute or two, the mineral has completely dissolved, with only a drop of clear, colorless liquid remaining (Finkelman and Mrose, 1977).

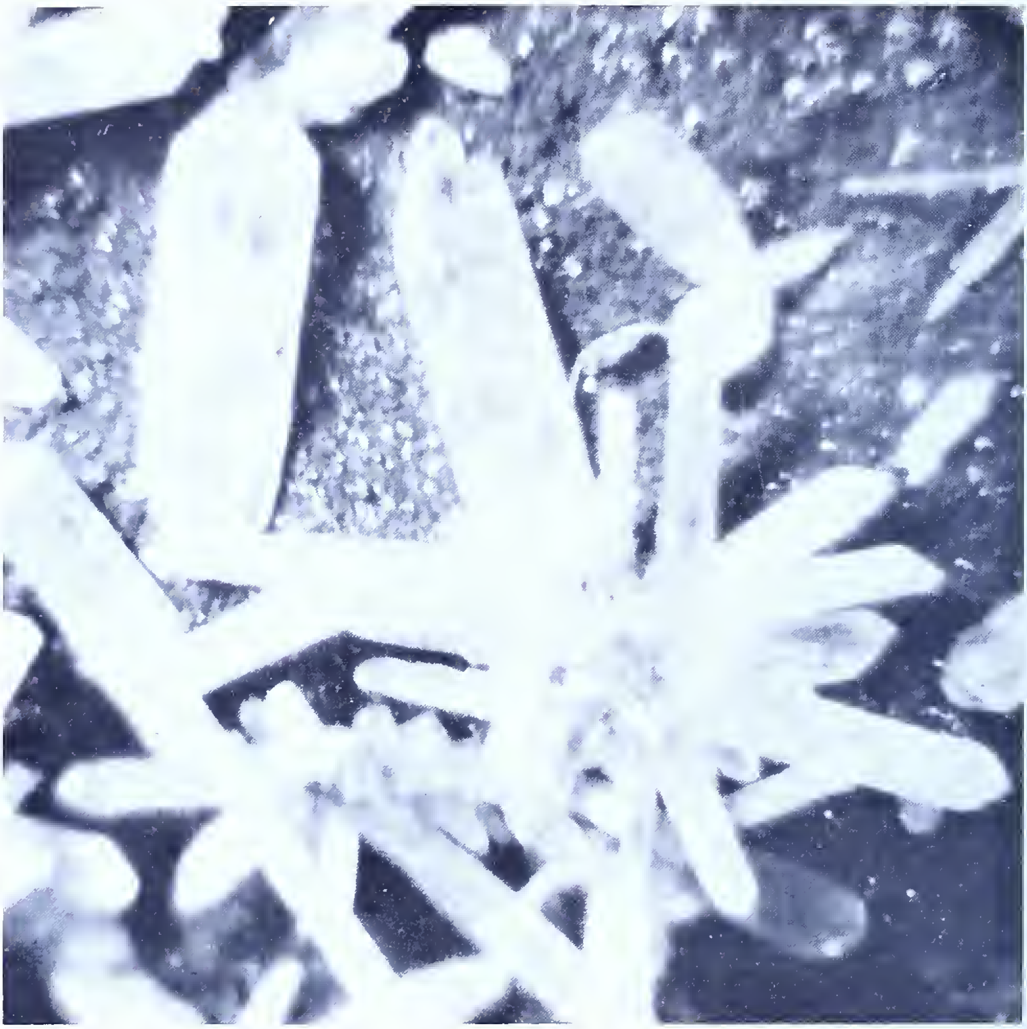

Figure 1: Downeyite (SeO_2) from a burning culm bank near Glen Lyon, Luzerne County.

Matulaite ($Ca(H_2O)_4[Al_9(OH)_{10}(PO_4)_6]_2 \cdot 24H_2O$) is shared by Pennsylvania with North Carolina and West Germany, where specimens were found by Rev. Douglas Berndt and Dr. Roland Dietrich, respectively. The mineral is named, however, for Mrs. Marge Matula, of Allentown, Pa., who provided samples from the Bachman Iron Mine, Hellertown, for the complete study. The mineral was described by Paul Brian Moore and Jun Ito (1980). Matulaite occurs as thin coatings on siliceous rocks associated with goethite and hematite iron ores. It is white with pearly luster and forms as small rosettes of thin, soft scaly crystals, botryoidal aggregates, and thin curved plates (Moore and Ito, 1980).

These recent discoveries are interesting not only in themselves, but in illustrating the potential that still remains for discoveries in a state as long settled, populous, and extensively explored as Pennsylvania. They also illustrate the fine cooperative relationship between amateur and professional mineralogist that this state has

enjoyed. All of these minerals were discovered by amateur mineral collectors. They were studied and named by professional mineralogists at Smithsonian Institution, The University of Michigan, the U.S. Geological Survey, and The University of Chicago.

REFERENCES

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Finkelman, R. B., and Mrose, M. E. (1977), *Downeyite, the first verified natural occurrence of SeO_2*; Am. Mineralogist, v. 62, p. 316-320.

Moore, P. B., and Ito, J. (1980), *Jungit und Matulait: Zwei neue taflige Phosphat-Mineralien*; Der Aufschluss, v. 31, p. 55-61.

EG-7 IS A SURVEY "BEST SELLER"

Heading the list of Survey best sellers for the past year and a half has been Bulletin EG-7, "Outstanding Scenic Geological Features of Pennsylvania" by Alan R. Geyer and William H. Bolles. Since its release in December of 1979, this publication has sold more than 1850 copies. For a geologic publication, this figure is impressive. In 1980 alone, approximately 1600 copies were sold.

The feedback from readers has been quite interesting. Planners are using it to identify outstanding geologic features in their area; a utility company is using it in preparing environmental impact statements for routing new transmission lines; many are planning recreational trips with visits to a particular geologic feature; and, of course, readers have told us they just enjoy reading about this aspect of Pennsylvania's landscape. With almost every letter comes a paragraph or two about an unusual geologic feature omitted or one we must not have known existed which they feel should have been included. In addition, many cited corrections and additions to the text and maps.

"Outstanding Scenic Geological Features of Pennsylvania" is still available from the State Book Store, P.O. Box 1365, Harrisburg, 17125. The cost of this 508-page book is very nominal at $4.50 per copy plus 27 cents sales tax if you are a resident of Pennsylvania. More than 350 of Pennsylvania's outstanding geologic and scenic features are described with a map location to each.

DISTINGUISHED FOREIGN VISITOR

Dr. Yousif Suleiman, Under Secretary of the Ministry of Energy and Mining in Sudan (North Africa) is shown being greeted by DER Secretary Clifford Jones, as Deputy Secretary Peter Duncan and State Geologist Arthur Socolow look on. Dr. Suleiman, a professional geologist and hydrologist, and former Director of the Sudanese Geological Survey, spent three days in April as guest of the Pennsylvania Geological Survey and DER. He was particularly interested in Pennsylvania's technical and administrative procedures pertaining to mining operations and water resources development.

Dr. Suleiman is being sponsored by the Eisenhower Fellowship Foundation of Philadelphia on a three month visit across the United States. His stops include several federal agencies, some prominent research institutes, a few of our major research oriented industries, and several universities. The Pennsylvania Geological Survey was selected by the Eisenhower Foundation as an appropriate state organization with program and research activities of direct relevance to Dr. Suleiman and his nation. We were pleased to be able to exchange information with our distinguished visitor.

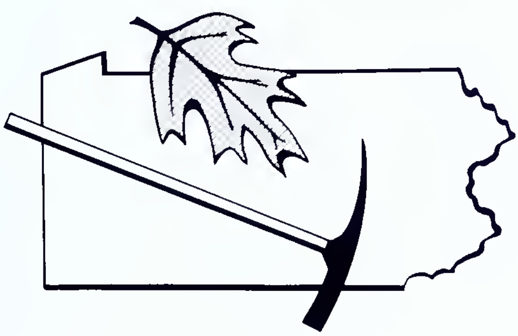
1981 Field Conference of Pennsylvania Geologists

The Annual Field Conference of Pennsylvania Geologists will be held in the north-central part of the state this year—a first in the 46-year history of the annual conference. The October 1, 2, and 3 meeting will focus on the general geology of Tioga and Bradford Counties, and will cover aspects of the bedrock stratigraphy and structure, glacial history, geomorphology, paleontology, coal geology, and engineering geology. Wellsboro will be the conference headquarters this year. Field trip stops will include outcrops near Burlington, Towanda, Franklindale, and LeRoy in Bradford County, and Tioga, Liberty, Morris, and Antrim in Tioga County. Of course, one of the field trip stops will be at Pennsylvania's Grand Canyon in Tioga County. Two of the stops will be at the new Tioga-Hammond Lakes Project.

The 1981 Field Conference is being organized by T. M. Berg of the Pennsylvania Geologic Survey. Other trip leaders include: D. M. Hoskins, W. D. Sevon, and J. P. Wilshusen (Pa. Geologic Survey); G. H. Crowl (Ohio Wesleyan Univ.); W. E. Edmunds (Consultant, Camp Hill); W. Franklin (U.S. Corps of Engineers); P. B. Luce (Mansfield State College); H. Pohn (U.S. Geological Survey); and D. L. Woodrow (Hobart & William Smith Colleges).

Tioga and Bradford Counties will provide an exciting array of geological wonders for Conference participants, but will also provide a visual feast because of the magnificent fall colors for which the counties are famous.

The conference is intended for professional geologists and graduate geology students. If your name is not already on the Field Conference mailing list, you may have it entered by sending your request to: Field Conference of Pennsylvania Geologists, c/o Pa. Geologic Survey, Box 2357, Harrisburg, PA 17120.



SURVEY ANNOUNCEMENTS

SAM W. BERKHEISER, JR., JOINS SURVEY

Sam W. Berkheiser, Jr., joined the Bureau of Topographic and Geologic Survey in April 1981 as an economic geologist with the Mineral Resources Division in Harrisburg.

Mr. Berkheiser received an A.B. in Geology from Catawba College in 1971 and an M.S. in Geology from Eastern Kentucky University in 1974. He previously has been employed by the Atlantic Richfield Company's Synthetic Crude and Minerals Division, and most recently with Dunn Geoscience Corporation. His experience includes projects involving aggregates, cement, clays, barite, basic refractories and various other industrial minerals.

Sam's responsibilities will include field investigations and resource studies of the State's industrial minerals. This will help to provide a better inventory of these important minerals and will serve the needs of planners, property owners, and the mineral development industry.

MARTHA WALTER RETIRES

Mrs. Martha Walter, data analyst with the Environmental Geology Division, retired on June 24th after completing almost 14 years of continuous, dedicated State service—the last 4 years with the Bureau of Topographic and Geologic Survey.

Martha, a native of Warren, Pennsylvania, started with the Commonwealth in the Department of Health, Bureau of Vital Statistics as a clerk. From this position she advanced in the Health Department to an Administrative Officer in the "old" Bureau of Sanitary Engineering. When this bureau became part of the Department of Environmental Resources, she was assigned to the DER's Bureau of Water Quality Management in January 1971.

Since 1977, Martha has brought to the Survey's water well inventory program, an efficient and highly professional performance and service to all.

Martha plans to spend more time with her children and enjoy her new home in the Pocono's. We wish her the best in her future activities.

Distribution of Geologists in Pennsylvania 1974 - 1980

by Pauline F. Silsley and Reginald P. Briggs
Geomega, Inc., Pittsburgh

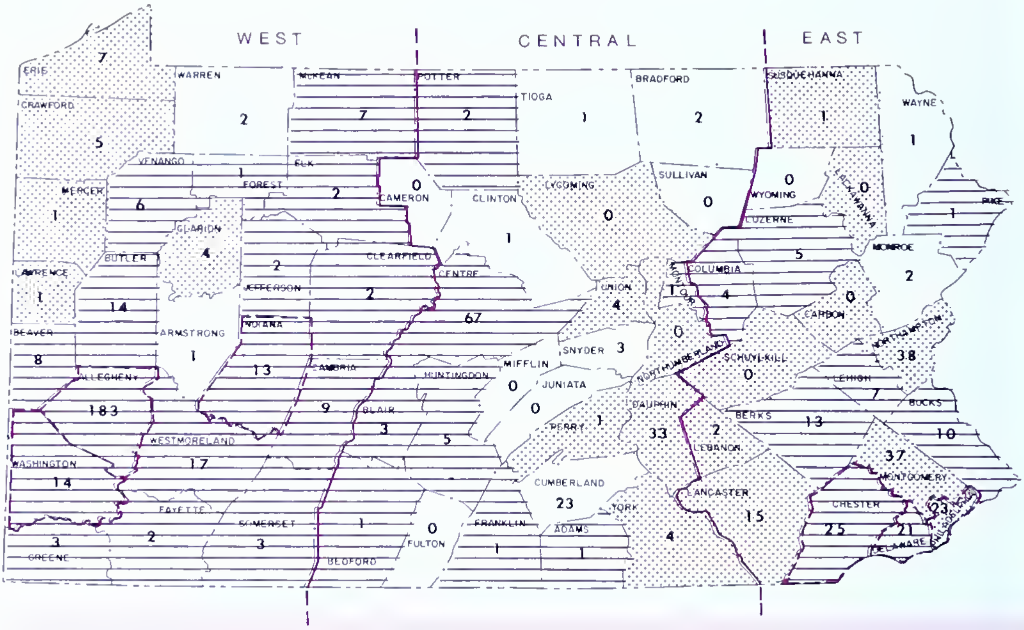
In the June 1975 issue of "Pennsylvania Geology" we reported that 586 geologists in Pennsylvania were listed in the 1974 annual directories of one or more of the following: Geological Society of America, American Association of Petroleum Geologists, American Institute of Professional Geologists, and Association of Engineering Geologists. It was noted that this number certainly did not include all geologists in Pennsylvania, an extrapolation of the fact that almost half of the 200-plus members of the Pittsburgh Geological Society belonged to none of the cited four National societies.

Now, six years later, we have examined the 1980 directories of the same National societies and find significant change. Last year there were 665 listed geologists, a 13.5 percent increase in a state with declining population. In 1974 there was one listed geologist for every 20,000 residents (1970 census figures); in 1980 one for every 17,700 residents (1980 census figures).

Moreover, this change is not just the result of building on a more or less stable core of "veteran" Pennsylvania geologists. Rather, the 1974 to 1980 comparison shows clearly what we have seen told all along; ours is a pretty mobile profession. Of the original 586, fewer than half remain listed in Pennsylvania.

Of the about 300 gone, 128 are now listed elsewhere. Texas claimed 29, Colorado 11, California 10, four other states at least 5 each, 48 are scattered through twenty-nine more states, and 8 went foreign. At least 5 geologists we know have died in the interim and another 15 or so we know have dropped out of society membership for a variety of reasons. But that leaves about 150 unaccounted for; they too are no longer listed in any of the four directories. They certainly have not all retired, died, or gone into other lines of work.

As a speculation, a factor may be the recent costs of membership compared to what is perceived as the value of membership. Many may have simply resigned or less formally dropped their memberships, and they may still be geologizing in Pennsylvania. In any case, the missing 150 are a puzzle that deserves attention.



Map showing numbers of geologists listed in 1980 and counties that gained or lost geologists 1974 to 1980. Horizontal lines—gain. Stippled—loss. No pattern—unchanged. Solid heavy lines separate informal zones. Counties with most significant gains or losses outlined by heavy dashed lines (see table 1).

Table 1. Pennsylvania Counties With Ten or More Geologists Listed In 1980, Compared to 1974

1980	1974	County	Number of Geologists 1980	Number of Geologists 1974	Growth (Decline) 1974 to 1980 numbers	Growth (Decline) 1974 to 1980 percent	Number of Geologists per 17,700 population[1/] 1980
1	1	Allegheny	183	136	47	34.5	2.2
2	2	Centre	67	57	10	17.5	10.7
3	3	Northampton	38	45	(7)	(15.5)	3.0
4	5	Montgomery	37	39	(2)	(5.2)	1.0
5	5	Dauphin	33	39	(6)	(15.4)	2.6
6	10	Chester	25	11	14	127.3	1.5
7 tie	7	Cumberland	23	23	0	0	2.3
7 tie	4	Philadelphia	23	42	(19)	(45.2)	0.2
9	10	Delaware	21	11	10	90.9	0.7
10	9	Westmoreland	17	12	5	41.7	0.8
11	8	Lancaster	15	21	(6)	(28.5)	0.8
12 tie	14	Butler	14	9	5	55.5	1.7
12 tie	21	Washington	14	5	9	180.0	1.2
14 tie	15	Berks	13	8	5	62.5	0.7
14 tie	21	Indiana	13	5	8	160.0	2.7
16	17	Bucks	10	6	4	66.7	0.4

[1/] Statewide mean is 1 geologist per 17,700 population (1980 census).

Making up for those gone elsewhere or otherwise lost are an even larger number of new names, but time forbade attempting to trace them backwards. We guess a sizeable proportion are young geologists who had not their degrees or who had not yet joined in 1974. Clearly another large contingent results from the energy boom now under way in western Pennsylvania; more experienced geologists have been transferred here by their companies.

In the 1975 article, a map showed distribution of geologists by county, and a table showed the 11 counties (11 as there was a tie for 10th place) with greatest numbers of listed geologists in 1974. The enclosed Table 1 shows that the top 11 counties are the same as 6 years ago, but there are significant changes in numbers and order. In Philadelphia, for example, listed geologists declined by close to half, and rank changed from 4th to a tie for 7th. Chester County now is 6th. Allegheny County is a reinforced number 1 with almost thrice the numbers of 2d-place Centre County, but Centre County (Penn State) remains by far the leader in geologists per total county population, with just over 10 times the state average.

As the table shows, the chief geological centers of 1974 remain those of 1980. However, the enclosed map illustrates a trend in growth of geological populations. Eastern, central and western zones of respectively 20, 24, and 23 counties are separated by heavy lines (without official significance). In the eastern and central zones, counties show a mixture of gains (notably Chester and Delaware), losses (most notably Philadelphia), and stability of geological populations. In each of these two zones, though, the summary 1974 to 1980 change is zero. In contrast, in the western zone, only 7 counties had losses or were stable and 16 show more geologists. In addition to Allegheny County's almost startling gain of 47, Butler, Indiana, Washington, and Westmoreland Counties each added 5 or more. The western zone accounted for *all* the gain in total listed Pennsylvania geologists from 1974 to 1980. During that period many young geologists took Greely's advice and went west to where the jobs are.

A RARE ASTRONOMICAL DISPLAY

The climax of this year's Great Conjunction, which is actually a triple conjunction of Jupiter and Saturn, will take place on the evenings of August 31 and September 1 when the three brightest planets, Venus, Jupiter, and Saturn; the first magnitude star, Spica;

and the crescent moon will appear together in the western sky soon after sunset.

The first of the three conjunctions took place on December 31, 1980; the second on March 4, 1981; and the third will take place on July 24, 1981. These planets move so slowly among the stars that an event of this type is very rare, not occurring again for 257 years. A discussion of these dates and their significance can be found on pages 224 and 225 of the March, 1981 issue of *Sky and Telescope*.

These two planets are extremely close visually during the first eight months of 1981 and periodically form attractive groupings with the moon. Prior to the month of March they could be best seen in the morning before sunrise; after March they are best observed in the night sky after sunset.

On April 16th, the moon, approaching full, will be close to Jupiter and Saturn and will be to the east of them on the night of April 17.

In May, the best nights for close grouping of the moon and the planets will be May 13, when the moon, just past quarter phase, will be west of the planets, and May 14, when it will be east of them.

The dates of June 9, 10, and 11 will again have the moon close to the planets at the first quarter phase. The closest groupings will be June 10.

In July, the moon and the planets will again appear close on the nights of the sixth and seventh, and again on the third of August.

All of the preceding, though impressive, are preliminary to the wonderful display beginning about August 24, when Jupiter and Saturn are joined by Venus. This grouping, appearing low in the west-southwest in the evening twilight, continues to the end of August. On August 31 and September 1, the three planets with the crescent moon and the first magnitude star, Spica, will be lined up. Be sure to remember to watch the western sky on the nights of August 31 and September 1.

In addition to the *Sky and Telescope* reference made earlier, additional information can be found in an article on the Great Conjunction in the February, 1981 issue of *Astronomy* and a special report on the Great Conjunction prepared by the staff of the Abrams planetarium of Michigan State University.

William H. Bolles
Science Education Adviser
PA Department of Education

PENNSYLVANIA GEOLOGICAL SURVEY STAFF

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Donald M. Hoskins, *Assistant State Geologist*

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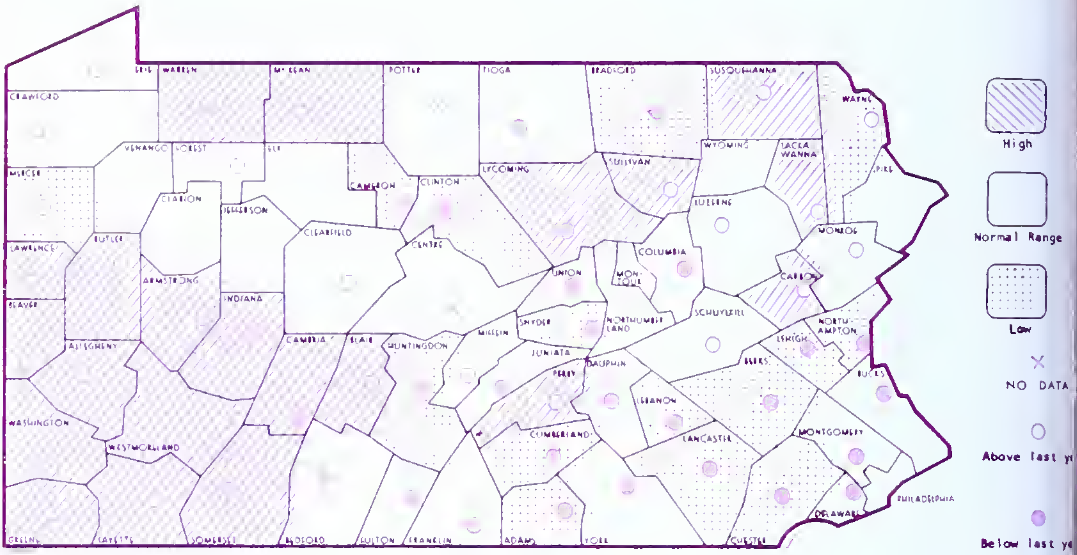

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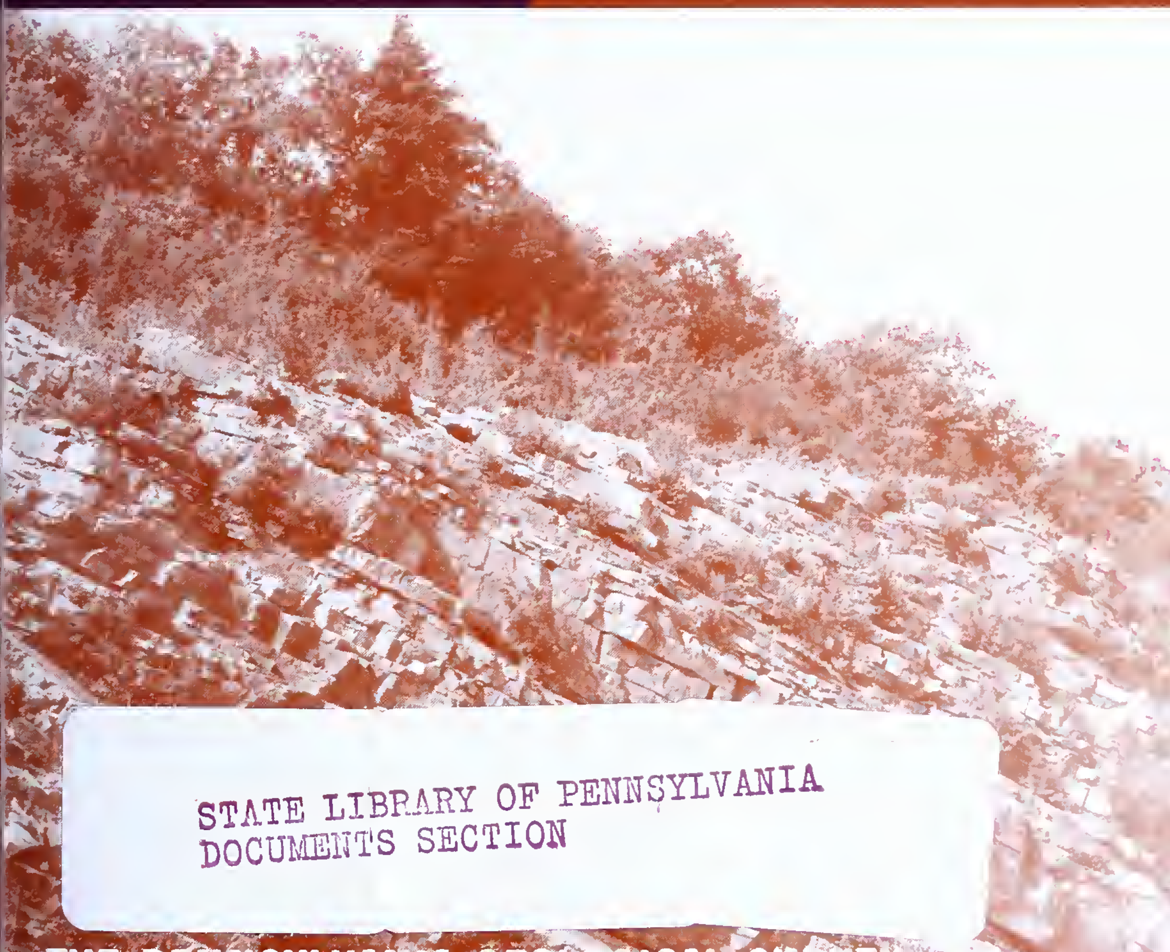
PENNSYLVANIA GEOLOGY



THE PENNSYLVANIA GEOLOGICAL SURVEY

COMMONWEALTH OF PENNSYLVANIA
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DEPARTMENT OF ENVIRONMENTAL RESOURCES
Clifford L. Jones, Secretary

OFFICE OF RESOURCES MANAGEMENT
Peter S. Duncan, Deputy Secretary

TOPOGRAPHIC AND GEOLOGICAL SURVEY
Arthur A. Socolow, State Geologist

CONTENTS

ON THE COVER: Well exposed, northward dipping quartzite beds of the Tuscarora Formation along U.S. Route 15, 2.5 miles east of South Williamsport, Lycoming County. Intersecting joint fractures create a rockfall problem which requires protective fencing along the highway.

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AUGUST 1981

FROM THE DESK

OF THE

STATE GEOLOGIST . . .

CRISIS ACTIONS OR PREVENTIVE ACTIONS — A CHOICE

Some twenty years ago we entered an era when planning became a respectable word in most fields, including science, government, academic and social work. There was great hope (and expectation) that America's propensity for "decision by crisis" would be replaced by the more efficient and effective process of progress by orderly planning and implementation. In large measure the great hope has not materialized. For whatever reason, the charisma and respect for orderly planning appears to have faded; it may be due in part to the fact that so often planning was not followed by implementation, leaving the image of planning as an abstract, non-utilitarian process.

The August 7th New York Times editorial headline reads, "The Mineral Problem Is Not A Crisis." It goes on to list a number of facts (actually called facts by the paper) including "America imports more than half its supply of some 20 strategically important minerals" and "Several of these come from unfriendly or politically vulnerable countries, including the Soviet Union, South Africa, and Turkey." Then, after commenting on these facts and the U.S. Government's plans for remedial actions, the paper comes to a fascinating conclusion: "It's prudent to worry about dependence on mineral imports. It is foolish to let these worries produce a blind rush for import independence."

I find their conclusions amazing! By the newspaper's logic, to worry is O.K., to do something about it is "foolish." And since when has federal action deserved the characterization of "blind rush"? Many of us have long been convinced that the U.S. is vulnerable to foreign sources of raw materials essential to our economy, as well as our security. The 1973 oil embargo was a lesson by crisis. Do we have to wait for another crisis in order to act?

The challenge of implementing action by other then crisis is not limited to federal or national issues. State and local programs face that challenge. The recent drought, somewhat alleviated by moderate rainfall, leaves one wonder if adequate plans and procedures will be implemented before the next drought period comes around—or will we do essentially nothing, as was the case after the drought of the mid-sixties? And those of us in Pennsylvania who were directly affected by the Agnes and Eloise floods of 1972 and 1975 are still looking about for tangible evidence that something will be done to prevent such future disasters.

There are actions that can be taken to forestall, or at least mitigate such problems as outlined above. But when such a prestigious newspaper as the New York Times says go slow, because the "—Problem Is Not A Crisis" it is a sign that reaction to crisis still previals as the dominant decision making process.

We can do better. Mankind is supposedly blessed with the ability to reason and to learn from experiences of the past. It is time to convert from crisis decisions to the much less costly, more effective process of preventive actions.

Arthur A. Socolow

GEOLOGICAL RESEARCH IN PENNSYLVANIA 1981

INTRODUCTION

This publication is the twenty-fourth annual report on Geological Research and Publications in Pennsylvania. This is an attempt to list all current geologic research in Pennsylvania and *includes persons and projects other than those of the Pennsylvania Geological Survey.* Because of the large number of projects reported to us, we exercise editorial license to reduce the description of the research projects to fit our available space.

We have also attempted to determine an anticipated completion date (ACD) for each project. The anticipated completion date is the estimate of the date when the author will complete his report; additional time should be anticipated until the report is published. If you wish more information on a project described herein, please write directly to the author; most of these projects will *not* be published by the Pennsylvania Geological Survey inasmuch as most are not Survey staff projects.

The listings are grouped into major categories of research to facilitate your search for information on a particular subject. Reports published are listed alphabetically by author.

As with all compilations, there may be omissions; this is unintentional. Additional copies of this report may be obtained by writing to the Bureau of Topgraphic and Geologic Survey, Department of Environmental Resources, P.O. Box 2357, Harrisburg, Pennsylvania 17120.

AREAL GEOLOGY

ROBIN ABEL, The Pa. State Univ., and T. M. BERG and W. D. SEVON, Pa. Geol. Survey. Lithologic Map of Pennsylvania. This map will show (at a scale of 1:500,000) about 25 rock units across Pennsylvania and is being derived from the new state geologic map. ACD: Early 1982.

J. D. INNERS, Pa. Geol. Survey. Geology and Mineral Resources of the Allenwood and Milton Quads., Lycoming, Union, Northumberland, and Montour Cos., Pa. ACD: 1983.

P. T. LYTTLE, Project Chief, U.S. Geol. Survey. Newark 2-Degree Quad. Reconnaissance geologic mapping of the southern part of the Triassic-Jurassic Newark Basin and adjacent Paleozoic and Proterozoic rocks of the Pennsylvania Piedmont will take place during FY 1981. Detailed reconnaissance of the major faults in this terrane will be carried out with particular emphasis on the Huntingdon Valley fault, the Cream Valley fault, and the Rosemont fault. ACD: Continuing.

HOWARD POHN and A. R. TAYLOR, U.S. Geol. Survey, G. H. CROWL, Ohio Wesleyan Univ., G. W. COLTON, U.S. Geol. Survey, retired, and T. L. PURDY, U.S. Geol. Survey. Geology and Mineral Resources of the Jersey Shore Quad., Clinton and Lycoming Cos. Field mapping of the bedrock geology is complete, and office compilation of final copy is well underway. Unusually complex faulting, folding, and disturbed zones occur in this area along the Allegheny Front. The field mapping of Pleistocene and other surficial deposits is underway (Crowl). ACD: Dec. 1981.

H. W. SCHASSE, Wash. Dept. of Natural Resources, and D. B. MacLACHLAN, Pa. Geol. Survey. Geology and Mineral Resources of the Conyngham Quad., Luzerne and Schuylkill Cos. Geologic mapping completed by Schasse; coal reserves currently under investigation by MacLachlan.

W. D. SEVON and T. M. BERG, Pa. Geol. Survey, L. D. SCHULTZ, Gilbert Assoc., and G. H. CROWL, Ohio Wesleyan Univ. Geology and Mineral Resources of Pike Co., Pa. ACD: Oct. 1, 1981.

A. N. WARD, JR., Slippery Rock St. Coll. Bedrock Mapping of Titusville N. and S. 7½ ′ Quads. ACD: 1985.

J. H. WAY, Pa. Geol. Survey. Geology and Mineral Resources of the Washington and Millville Quads., Montour, Columbia, and Northumberland Cos., Pa. Geologic mapping of bedrock and surficial deposits, defining and sampling materials with possible economic potential, and describing environmental and engineering characteristics of all geologic units in the area. ACD: 1982.

ECONOMIC GEOLOGY

K. D. ABEL, Pa. Geol. Survey. Oil Fields of Southwestern Pa. The report will be a summary of the history and geology of the oil fields of Allegheny, Beaver, Greene, and Washington Counties. ACD: Sept. 1981.

S. W. BERKHEISER, JR., Pa. Geol. Survey. Preliminary Reconnaissance of Potential Carbonate "Whiting" in South-Central and Southeastern Pa. Preliminary test results are interpreted to suggest that the most favorable source rocks may underlie parts of Chester and York Counties. Test results include dry brightness and chemical analysis for identified sources. ACD: Aug. 1981.

R. P. BRIGGS, Geomega, Inc. Reconnaissance Reexamination of Mineral Potential of the State Line District, Md. and Pa. [Chester and Lancaster Cos., Pa., and Cecil Co., Md.]. ACD: Fall 1981.

S. H. CLARK, Project Chief, U.S. Geol. Survey. Lead-Zinc-Barite-Fluorite Resources of the East-Central U.S. Initial data compilation from a literature review for the States of New York, Pennsylvania, West Virginia, Kentucky, Virginia, Tennessee, Alabama, Illinois, Michigan, Wisconsin, Georgia, Ohio, and Indiana will be completed in FY 1981. This will include contacting people familiar with deposits and occurrences in each state in order to supplement data in the literature. Preliminary drafting of metallogenic maps for these states will also get underway.

W. E. EDMUNDS, Consulting Coal Geologist, and J. R. EGGLESTON, Skelly & Loy. Anthracite Coal Basins of Pa. Summary of the economic coal geology of the anthracite fields. ACD: June 1981.

W. E. EDMUNDS, Consulting Coal Geologist, and J. R. EGGLESTON, Skelly & Loy. Statistical Control of Anthracite Exploratory Drilling. The number of exploratory drill holes necessary to estimate the coal reserves of a property within predetermined limits and with a predetermined level of confidence can be determined by application of statistical probability formulas. ACD: 1982.

A. D. GLOVER, C. H. DODGE, J. R. SHAULIS, and V. W. SKEMA, Pa. Geol. Survey. Coal Resources of Greene, Washington, Allegheny, Fayette, Westmoreland, Beaver, Butler, Cambria, Indiana, and Somerset Cos. Data for coal-bearing strata in Greene, Washington, and Allegheny Counties have been entered into the National Coal Resources Data System (NCRDS) computer. Information for Fayette, Westmoreland, Beaver, Butler, Cambria, Indiana, and Somerset Counties is currently being assembled and prepared for entry into the system. This will result in computer-generated geologic and resource maps for western Pa.

J. A. HARPER and C. D. LAUGHREY, Pa. Geol. Survey, and W. S. LYTLE. Oil and Gas Fields Map of Pa. The map will show the oil and gas fields and will identify the producing formations in each.

A. G. HARRIS, Project Chief, U.S. Geol. Survey. Conodont Maturation Studies. Major emphasis during FY 1981 will be to use conodont color alteration indexing to assess the oil, condensate, and natural gas potential of Middle and Upper Devonian black shales in the Appalachian basin, and to provide conodont-based age determinations for correlation of the black shale succession in outcrops and boreholes. Age determinations and thermal analysis of black shale core samples obtained from Erie County, Pa., and Montgomery County, Ky., will be completed.

K. B. KETNER, Project Chief, U.S. Geol. Survey. Silica Resources of the U.S. Field work for FY 1981 has already been done in Tennessee, Virginia, West Virginia, Maryland, New Jersey, Pennsylvania, and New York. This consisted of reconnaissance of high-purity quartz arenites in the Tuscarora and Oriskany Fms. Samples were taken for mineralogical and chemical analyses. Compiling a map of these units will contribute to an eventual assessment of the national high-grade silica resource base. ACD: Continuing.

ANTON KLAVER, Mobil Oil Co. Evaluation of the Economic Potential of Devonian Black Shales. ACD: Ongoing.

C. D. LAUGHREY, Pa. Geol. Survey. Geology of the Kane Sand, Cush Cushion Field, Indiana Co., Pa. Development drilling in eastern Indiana County has defined a limited but substantially productive Upper Devonian sand trend. The reservoir is described and explained. The report includes two cross sections and three maps which illustrate the trend. ACD: April 1981.

G. W. LENEY, U.S. Dept. of Energy, and BENDIX FIELD ENGINEERING CORPORATION. National Uranium Resource Evaluation Program (NURE) [entire U.S.]. Work carried out in Pennsylvania includes portions of reconnaissance airborne radiometric surveys, hydrogeochemical and stream sediment reconnaissance surveys, and supplementary analytical work, geologic evaluations for favorability for the occurrence of uranium deposits, and research projects. ACD: 1983.

F. G. LESURE, U.S. Geol. Survey. Cornplanter Roadless Area, Pa. Mineral resource assessment of area. ACD: Dec. 1981.

J. S. LEVENTHAL, Project Chief, U.S. Geol. Survey. Uranium and Trace Elements in Devonian Black Shale. This project has been extended for a portion of FY 1981 to complete work on organic matter, trace elements, and uranium in Devonian black shales from the Appalachian Basin. This will include determination of geochemical

controls, uranium resources, and sulfur-carbonate isotope relationships. Relationship of geochemistry to depositional environment, mineralogy, and stratigraphy will also continue. ACD: Sept. 1981.

R. W. LUCE, Project Chief, U.S. Geol. Survey. Metallogeny of Acid Altered Volcanogenic Mineral Deposits. Maps showing mineral deposits in the Appalachian Orogen that contain significant amounts of gold, pyrophyllite, kyanite, topaz, tourmaline and(or) hydrothermal clays will be compiled and, where possible, categorized as to size, type, and mineral assemblage during FY 1981. The location of the deposits will be plotted on 1:1,000,000 lithofacies, lineament, aeromagnetic, gravity, and radiometric maps. Genetic interpretation will be made of the resulting relationships. ACD: Continuing.

J. B. ROEN, Project Chief, U.S. Geol. Survey. Stratigraphy of Devonian Black Shale in Appalachian Basin. Reports on the ash fall nomenclature in the Appalachian Basin, the Tully Limestone, the areal distribution of the New Albany, Chattanooga, and Ohio Shales in Kentucky, and the final report documenting the results of this project will be prepared for publication. ACD: Sept. 1981.

J. W. SCHMOKER, Project Chief, U.S. Geol. Survey. Borehole Gravity Survey, Devonian Black Shale, Appalachian Basin. Final report writing on the organic matter content of the Devonian Shale and a summary report, including contributing information to the resource appraisal being developed for the Appalachian Basin, will take place in the first half of FY 1981. ACD: Sept. 1981.

S. P. SCHWEINFURTH, Project Chief, U.S. Geol. Survey. Pennsylvania RARE II Areas. RARE II areas in Pennsylvania will be mapped and geochemically sampled during FY 1981 in order to determine the mineral resource potential of each area. Reports and maps documenting the results of these investigations will be prepared for publication. ACD: Sept. 1981.

A. T. SMITH and A. W. ROSE, The Pa. State Univ. Regional Sedimentologic and Geochemical Controls for Red-Bed Copper and Uranium in the Devonian Catskill Fm. of Pa. The characteristics of the Catskill sedimentary basin and of diagenetic processes are being studied to evaluate factors involved in mineral deposition. Research includes isotopic studies of sulfur, carbon, oxygen, and lead, fluid inclusions formed during diagenesis, and computer modeling of pore-fluid movement during compaction. ACD: 1982.

R. C. SMITH, II, and J. H. BARNES, Pa. Geol. Survey. Geologic and Mineralogic Interpretation of Gamma-Ray Reconnaissance Data for the Reading Prong, Eastern Pa. [portions of Berks, Bucks, Lehigh,

and Northampton Cos.]. Lithologic samples have been taken of sites where gamma-ray anomalies have been detected with a carborne survey. Petrographic, mineralogic, and geochemical studies are in progress for those anomalies related to uranium mineralization. ACD: 1982.

R. C. SMITH, II, Pa. Geol. Survey, and D. T. HOFF, Wm. Penn Memorial Museum. Copper-Uranium Occurrences in the Catskill Fm., Picture Rocks and Sonestown Quads., Pa. [Lycoming and Sullivan Cos.]. Geologic and mineralogic studies of 50 small Cu-U bearing lenses have been completed and a report is being prepared. Quantitative analyses for U, Cu, As, and Pb are included for 60 channel samples as well as descriptions of several rare minerals. ACD: 1981.

R. B. WELLS, Consulting Geologist. Natural Gas Potential of the Ridgeley Sandstone in North-Central Pa. Petroleum reservoir conditions similar to the Salladasburg Gas Field are thought to exist in the Lower Devonian sandstones elsewhere in Lycoming and adjacent counties. The objective of this study is to identify those areas which have the greatest potential for economic natural gas production, utilizing both surface and subsurface geologic techniques. ACD: 1983.

ENVIRONMENTAL GEOLOGY

R. L. DAVIS, PENNY TAYLOR, MICHAEL GARDNER, and DEBORAH HENTON, Univ. of Pitt. at Bradford. Water Quality in the Bradford Water Supply System. There have been significant chemical (iron), physical (turbidity), and bacteriological (*Giardia*) problems in the Bradford water supply system. We are trying to identify the sources of these problems and to recommend management techniques to deal with them. ACD: Apr. 1982.

W. E. DAVIES, Project Chief, U.S. Geol. Survey. Safe Mine Waste Disposal. Investigation of clay minerals and the role of dispersive clays in landslides will continue, along with investigation of void sizes critical in debris avalanches and their significance with regard to different amounts of precipitation. Detailed studies of 7½-minute quadrangles within the Clarksburg, Bluefield, Pittsburgh, Canton, Charleston, Huntington, and Jenkins 2-degree quadrangles will be underway in FY 1981. These investigations include mapping "typical" landslides, movement measurement, and pore pressure and stratigraphic studies of selected landslides. ACD: Continuing.

N. K. FLINT, RICHARD YEAGER, and JAMES KRUSHIN, Univ. of Pitt. Project 1. Slope Stability and Landslide Hazards in the Little Sewickley Creek Watershed, Allegheny Co. Project 2. Slope Stability and Landslide Hazards in Indiana and Harmar Twps., Allegheny Co. These projects involve field mapping at a scale of 1 inch to 200 feet. Landslide-risk maps are color-coded for easy interpretation by municipal officials and other nongeologists. ACD: Project 1, Aug. 1981; Project 2, Dec. 1981.

MARK GERMINE and J. H. PUFFER, Rutgers Univ. Asbestos Distribution in the Precambrian Marble of Easton and Forks Twps., Pa. Asbestos varieties present include tremolite, actionolite, and chrysotile (a meerschaum-like variety). Potential environmental problems include contamination of an impounded water supply, excavations of bedrock and lower soil horizons, and neighborhood contact with quarry residuals. ACD: May 1981.

J. S. POMEROY, U.S. Geol. Survey. Slope Stability, Appalachians. Plans for 1981 include study in Oak Forest quad., Greene Co.

GENERAL GEOLOGY

W. M. JORDAN and R. M. BENSON, Millersville St. Coll. Relationships between Geology and Industry in 19th Century Pa. [Anthracite region]. ACD: Continuing.

WILLIAM KREIGER, Lock Haven St. Coll. Petrology of Bunker Hills Igneous Rocks [Bunker Hills, Lebanon Co., Pa., about 4 miles north of the city of Lebanon in Swatara Twp.] Preliminary reconnaissance of the Bunker Hills area and a literature search has been completed to date. Plans are for a petrographic study (optical and chemical analysis) of intrusive and extrusive igneous rocks in this area. ACD: 1984.

J. P. WILSHUSEN, Pa. Geol. Survey. Geology of the Appalachian Trail in Pa. [SE Pa.]. A description of geologic characteristics of each physiographic province with detailed, illustrated geologic accounts at points of interest along the route. Sketch maps with geologic cross sections and descriptions are keyed to a geologic map of the trail. ACD: July 31, 1981.

GEOCHEMISTRY

J. T. McNALLY and A. W. ROSE, The Pa. State Univ. Geochemistry of Carbonate Ground Waters as a Guide to Lead-Zinc Deposits in

Central and Eastern Pa. About 160 well waters from Lancaster, Franklin, and Blair Counties have been analyzed for Fe, Ca, Na, K, Mg, Mn, Sr, Ba, Cu, Pb, Zn, HCO_3, SO_4, NO_3, Cl, F, pH, conductivity, and dissolved oxygen. Contents of SO_4, Ba, Pb, and Zn are anomalous near at least some of the three known Pb-Zn occurrences that were studied. Saturation indices and interrelations of elements appear to improve the contrast of anomalies. ACD: 1981.

H. A. TOURTELOT, Project Chief, U.S. Geol. Survey. Environmental Geochemistry, Southeastern U.S. Urban geochemistry studies will continue in the Pittsburgh and Washington, Pa. areas. Efforts will be made to characterize the dioctahedral chlorite in flint clays collected in Missouri and Pennsylvania. ACD: Continuing.

J. W. TROESTER and W. B. WHITE, The Pa. State Univ. The Seasonal Variation of Carbon Dioxide in the Atmosphere of Tytoona Cave, Blair Co., Pa. The carbon dioxide content of the cave atmosphere is measured every two weeks by a Draeger multi-gas detector to determine the seasonal variation. Work began in spring, 1981. Concentrations several times atmospheric have been measured. ACD: Summer 1982.

GEOMORPHOLOGY

D. D. BRAUN, Bloomsburg St. Coll., and J. D. INNERS, Pa. Geol. Survey, Seismic Investigations of the Orangeville "Umlaufberg" and Tenmile Run Valley, Columbia Co., Pa. ACD: 1983.

W. E. DAVIES, U.S. Geol. Survey. River Terrace and Colluvial Deposits of the Potomac Basin. Continuation of mapping of terraces in the headwaters area of the Potomac, mainly along Licking Creek, Tonoloway Creek, and Sideling Hill Creek. ACD: 1983.

JACK DONAHUE and D. E. BEYNON, Univ. of Pitt. Geoarchaeology of Meadowcroft Rockshelter [Washington Co.]. Development of Meadowcroft Rockshelter in terms of shelter formation and then generation of the colluvial sediment cone beneath the shelter.

NOEL POTTER, JR., Dickinson Coll. Distribution and Origin of Gravels and Colluvium in Cumberland and Franklin Cos. ACD: Continuing.

ANNETTE RUSSO, Lafayette Coll. Fabric Analysis of Boulders in the Blue Rocks Block Stream [Lenhartsville, Pa.]. ACD: June 1981.

W. B. WHITE, The Pa. State Univ. Caves of Pa. Description and maps are being compiled for all known caves in Pennsylvania. Volunteer

cavers are field checking and resurveying caves as necessary. Data for Mifflin County were completed in 1980. ACD: Fall 1981.

W. B. WHITE and E. L. WHITE, The Pa. State Univ. Geomorphology of the Appalachian Karst [N.Y. to Ala.]. Quantitative analysis of landform morphology and underground drainage systems for selected karst regions throughout the Appalachians. Current work is a detailed description of the karst of the Valley and Ridge province of Pa. ACD: Continuing.

GEOPHYSICS

V. E. ALEO, City of Wilkes-Barre. Seismological History of Pa. A compilation of historical seismic activities throughout the state and their possible underlying causes. ACD: 1983.

W. H. DIMENT, Project Chief, U.S. Geol. Survey. Seismotectonics of Northeastern U.S. A rational scheme for seismic zonation of the northeastern U.S., through study of deep geologic conditions are revealed by analysis of gravity, magnetic, heat flow, and seismic and drilling data, will continue to be developed during FY 1981. ACD: Continuing.

V. A. SCHMIDT, JACK DONAHUE, and H. R. ROLLINS, Univ. of Pitt. Paleomagnetism of Carboniferous Sediments in the Appalachian Basin [W. PA., E. Ohio, W. Va.]. To date good paleomagnetic pole positions have been obtained for the Brush Creek, Buffalo, Vanport, Loyalhanna, Pottsville, Wymps Gap, and Greenbrier Fms. In addition, polarities have been determined for many others. All but the Wymps Gap and Greenbrier display reversed polarities. ACD: 1983.

GLACIAL GEOLOGY

E. B. EVENSON and JAMES COTTER, Lehigh Univ., L. A. SIRKIN, Adelphi Univ., and W. D. SEVON, Pa. Geol. Survey. Wisconsinan Deglaciation Chronology of Northeastern Pa. and Northwestern N.J. In an attempt to establish a radiocarbon controlled deglaciation chronology for northeastern Pa. and northwestern N.J. 28 lakes and bogs have been cored. Those with basal late-glacial pollen assemblages have been sampled for radiocarbon analysis. No dates are currently available. ACD: Jan. 1982.

JACK RIDGE and E. B. EVENSON, Lehigh Univ., and CARL KOTEFF, U.S. Geol. Survey. [No title given.] Detailed surficial mapping was

completed using the morpho-sequence concept. Combined map, provenance and soil analyses were used to reconstruct Wisconsinan maximum positions, geometry of deglaciation, and changing ice flow patterns and to provide base map information for stratigraphic and palynologic studies. ACD: Winter 1981-1982.

HYDROLOGY

A. E. BECHER, U.S. Geol. Survey. Ground-Water Resources of Anthracite Areas in and near Schuylkill Co., Pa. ACD: Sept. 1982.

D. K. DAVIS and R. A. SLOTO, U.S. Geol. Survey. Geology and Ground Water Resources of Pike Co., Pa. ACD: Sept. 1983.

J. M. GERHART, U.S. Geol. Survey, and G. J. LAZORCHICK, Susquehanna River Basin Comm. Numerical Models of Major Aquifers in Lower Susquehanna River Basin, Pa. ACD: Mar. 1983.

T. A. McELROY, Pa. Geol. Survey, The Groundwater Resources of Fayette Co., Pa. ACD: June 1982.

G. N. PAULACHOK and C. R. WOOD, U.S. Geol. Survey. Appraisal of the Ground Water Resources of the Philadelphia Area, Pa. Objectives are to assess the quantity and quality of water available from aquifers underlying Philadelphia and to construct a predictive ground-water flow model. Well inventory, sampling, and geophysical logging have been completed. ACD: Mar. 1982.

D. W. ROYER, Pa. Geol. Survey. Summary Groundwater Resources of Lebanon Co. Description and inventory of groundwater resources of Lebanon County. Report will include a table of well records with selected chemical analyses, and a geologic map at a scale of 1:50,000. ACD: Dec. 1981.

R. A. SLOTO and D. K. DAVIS, U.S. Geol. Survey. Effect of Urbanization on the Quantity and Quality of Ground Water and Low Streamflow in Warminster Twp., Bucks Co., Pa. ACD: Sept. 1981.

D. E. STUMP, U.S. Geol. Survey. Hydrology of the Big Sandy Creek Basin, Fayette Co., Pa. ACD: Sept. 1981.

L. E. TAYLOR, Pa. Geol. Survey, and WILLIAM WERKHEISER and M. L. KRIZ, Susquehanna River Basin Comm. Groundwater Resources of the West Branch of the Susquehanna River Basin, Pa. ACD: Jan. 1, 1982.

D. P. VOYKIN, Pa. Dept. of Environmental Resources, P. B. MYERS, JR., Group Manager, Lehigh Univ., and C. W. WESTLUND, Project

Manager, Pa. Dept. of Environmental Resources. Aquifer Designation Study [State of Pa.]. Object of the study is to describe and delineate Pennsylvania's ground-water basins as accurately as possible using existing data and hydrogeologic judgement. ACD: Sept. 30, 1981.

D. W. WILLIAMS, J. D. STONER, and others, U.S. Geol. Survey, and C. H. DODGE, Pa. Geol. Survey. Water Resources and the Effect of Coal Development in Greene Co., Pa. ACD: Mar. 1982.

D. R. WILLIAMS and J. D. STONER, U.S. Geol. Survey. Ground-Water Resources of Greene Co., Pa. ACD: Sept. 1982.

J. H. WILLIAMS, U.S. Geol. Survey, and G. E. SENKO, Susquehanna River Basin Comm. Ground-Water Resources of Montour and Central Columbia Cos., Pa. ACD: Sept. 1982.

J. H. WILLIAMS, U.S. Geol. Survey, and G. E. SENKO, Susquehanna River Basin Comm. Numerical Model of Bedrock and Alluvial-Outwash Aquifers of the Susquehanna Valley between Berwick and Bloomsburg, Pa. ACD: Feb. 1982.

C. R. WOOD, U.S. Geol. Survey. Ground-Water Quality and Flow in the Coastal Plain Aquifer, Philadelphia Area, Pa. ACD: Sept. 1981.

IGNEOUS AND METAMORPHIC PETROLOGY

B. C. HEARN, Project Chief, U.S. Geol. Survey. Geology of Kimberlite. Reconnaissance investigations of kimberlites in Kentucky, Virginia, and Pennsylvania are planned for FY 1981. ACD: Continuing.

W. K. SCWRYBA and G. H. MYER, Temple Univ. Amphibolites in the Wissahickon Group, Philadelphia Area, Pa. Petrography and major element chemistry of amphibolites in the Philadelphia area were studied to determine their precursor material. Igneous material of tholeiitic character is the indicated parent material. ACD: May 1981.

MINERALOGY

M. E. MROSE, Project Chief, U.S. Geol. Survey. Mineralogical Investigations. Project will continue to characterize the physical,

optical, and chemical properties of new minerals, as well as those for which insufficient criteria for identification exists. During FY 1981, two areas of emphasis will be on completing a mineralogical/chemical study of Nd-rich carbonate hydrate ("lanthanite") from Saucon Valley, Pennsylvania, and continuing a mineralogical and crystallographic study of minerals found associated with burning culm banks in Pennsylvania.

PALEONTOLOGY

J. A. HARPER, Pa. Geol. Survey. Fossils of the Pittsburgh Area—A Guide to Collecting in the Tri-State Region. A fossil-hunter or rockhound's guide to fossils in western Pennsylvania, eastern Ohio, and northern West Virginia. Will include localities and identification references. ACD: Indefinite.

A. G. HARRIS, Project Chief, U.S. Geol. Survey. Conodont Succession Across the Lower/Mid-Ordovician Boundary, Central Appalachian. Analysis of samples collected during FY 1980 in the Valley and Ridge province of Virginia, Maryland, West Virginia, Pennsylvania, New Jersey, and New York will be completed. Collections from key sections in central Pennsylvania and Virginia will be refined. A report on the Lower Middle Ordovician of the central Appalachians will be prepared. ACD: Continuing.

D. M. HOSKINS and J. D. INNERS, Pa. Geol. Survey. Fossil Collecting in Pa. (2nd ed.). ACD: 1982.

J. D. INNERS, Pa. Geol. Survey. Paleontologic Reference Collection [state-wide]. New material recently added to the collection includes many specimens from the following stratigraphic intervals and geographic areas: Mahantango Fm.—Montour and Columbia Counties; Onondaga Fm.—central Pa.; Keyser and Tonoloway Fms.—Union and Northumberland Counties; Greenbrier Limestone—Fayette and Somerset Counties; Conemaugh marine zones—western Pa.; and Trimmers Rock Fm.—Luzerne and Columbia Counties. ACD: Ongoing.

W. F. KLOSE, II, Paleontological Research Institute. Contributions to the Pennsylvanian Age Flora and Fauna of the Anthracite and Semi-Anthracite Coal Fields of NE Pa. Collection of Pennsylvanian age flora and fauna with deposition of prepared specimens in the William Penn Memorial Museum, Harrisburg. ACD: Ongoing.

W. F. KLOSE, II, Paleontological Research Institute. Paleobotony of the Roof Shales of the Bernice "C" Semi-Anthracite (Allegheny Series), Sullivan Co., Pa. ACD: 1984.

G. R. McGHEE, JR., Rutgers Univ., J. M. DENNISON, Univ. of N. Carolina, and R. G. SUTTON, Univ. of Rochester. Late Devonian Benthic Marine Communities of the Allegheny Front in Pa. The project concerns the marine paleoecology and paleoenvironments of Late Devonian fauna/habitats as preserved in Frasnian (Senecan) age strata along the Allegheny Front in Pa. These strata have variously been described as the Chemung, Foreknobs, Trimmers Rock, and West Falls in different regions of the Appalachian Basin. ACD: Open-ended.

SCOTT McKENZIE, independent amateur, and R. M. FELDMAN, Kent St. Univ. Devonian Horseshoe Crab from Erie Co., Pa. Specimens of the fossil horseshoe crab species *Protolionulus* have been found in Erie County, Pa. These new specimens, collected in 1979-80, are the first reported since 1895. Hypotypes will be described and photographed (one is the only known dorsal side of a *Protolionulus*) in an article now under preparation for the *Journal of Paleontology.* ACD: April 1981.

W. A. OLIVER, JR., and J. M. BERDAN, U.S. Geol. Survey. Upper Silurian-Lower Devonian Biostratigraphic Framework of the Central Appalachians. Pennsylvania part of project is primarily a study of the systematics and distribution of ostracodes and corals in the Keyser, Decker, and Helderberg Limestones. ACD: 1984.

DAVID STEPHENS, Hobart Coll. Trace Fossils of the Shallow-Water Marine Rocks (Upper Devonian) in Northern Pennsylvania: A Survey of Four Outcrops. ACD: June 1, 1981.

SEDIMENTOLOGY

EDWARD COTTER, Bucknell Univ. The Role of Coastal and Shelf Processes in the Origin of the Tuscarora Fm. of Central Pa. The Tuscarora was deposited in a variety of marine shelf, coastal, and terrestrial environments that shifted in space and time as a consequence of eustatic sea level changes. Additional field study and laboratory work to refine lithofacies characterization and interpretation should be completed this summer. ACD: Fall 1981.

S. T. PAXTON and E. G. WILLIAMS, The Pa. State Univ. Diagenesis of Carboniferous Sandstones and Shales and Possible Relationships to Regional Coal Rank Variation in Pa. [Anthracite and North Central Coal Fields]. ACD: 1981-82.

DONALD WOODROW, Hobart and William Smith Coll. Sedimentology of the Shallow-Water Marine Rocks in Selected Upper Devonian Outcrops in North-Central Pa. ACD: Aug. 31, 1981.

STRATIGRAPHY

R. J. BOTTJER and PAUL ENOS, SUNY at Binghamton, and DONALD WOODROW, Hobart and William Smith Coll. Depositional Environment of an Upper Devonian Sandy Coquinite [Case Quarry, Burlington, Bradford Co., Pa.]. Senior thesis project concerned with determination of the depositional environment of the Luthers Mills Coquinite Member (Towanda Fm.) at its maximum thickness (8.6 m). ACD: May 31, 1981.

J. R. EBERT, SUNY at Binghamton. Paleoenvironments of the Upper Helderberg Group [surface and subsurface of N.Y. and Pa.]. This project is a detailed outcrop and subsurface investigation of the lithofacies of the Becraft, Alsen, and Port Ewen Formations and their equivalents in eastern Pa. Stratigraphic relationship to the Pennsylvania section will be clarified and interpretations of paleoenvironments and reconstruction of paleogeography will be made. Preliminary field work has been completed and acquisition of subsurface information is currently underway.

W. E. EDMUNDS, Consulting Coal Geologist. The Mississippian-Pennsylvanian Boundary in Pa. Summary of the current understanding of the Mississippian-Pennsylvanian boundary in Pa. (including N.Y.). ACD: Nov. 1981.

K. J. ENGLUND, Project Chief, U.S. Geol. Survey. Pennsylvanian System Stratotype Study. Major effort during FY 1981 will be to collect and identify fossils from the Pennsylvanian Stratotype System. Several reports documenting the results of investigations conducted by this project are in preparation and these reports will continue to be processed through to publication. ACD: Continuing.

A. D. GLOVER, C. H. DODGE, J. R. SHAULIS, and V. W. SKEMA, Pa. Geol. Survey. TASIC (Temporarily Available Stratigraphic Information Collection). This project is a continuing program for recording stratigraphic data on active coal and clay strip mines while exposures are available. The ongoing project is designed to provide data for future mapping and regional mineral resource evaluation.

M. K. McINERNEY, W. Va. Univ., and T. M. BERG and D. B. MacLACHLAN, Pa. Geol. Survey. Stratigraphic Correlation Diagram of Pa. This correlation diagram will show the interrelation of all rock formations in Pennsylvania with reference to geologic time as presently understood. ACD: 1982.

H. B. ROLLINS and JACK DONAHUE, Univ. of Pitt., S. H. WARSHAUER, W. Va. Univ., and C. W. NORTON, Kent St. Univ. Microfaunal Biostratigraphy of Selected Carboniferous Marine Units within the Appalachian Basin. ACD: 1984.

STRUCTURAL GEOLOGY

T. H. ANDERSON, Univ. of Pitt., and MIKE RODGERS. The Extension of the Tyrone-Mt. Union Lineament in Northwestern Pa.—Geological, Geophysical, and Geochemical Characteristics. Geochemical analyses of hydrocarbons, very low frequency electromagnetic surveys, limited fracture studies, and surveys of published stratigraphic and structural data were utilized in an effort to characterize the northwest extension of the Tyrone-Mt. Union lineament. ACD: May 1981.

SEZGIN AYTUNA and A. M. JOHNSON, Univ. of Cincinnati. Form of Folds in the Central Appalachians [Loysville, New Bloomfield, and Millerstown Quads.]. Using published map data and additional dip data, a down-plunge structural cross section was prepared. The cross section shows that the folds typically are a combination of chevron-like and concentric-like. Future work will map a large fold near Northumberland, Pa. in order to determine the form of the fold and the study of deformation mechanisms. Theoretical analysis of scaled multilayers will be compared with the map patterns. ACD: June 1983.

PHILIP BERGER and A. M. JOHNSON, Univ. of Cincinnati. Mechanics of Fault-Related Folds [Shamokin, Pa.]. Work in progress consists of theoretical analysis and petrofabric study of a small (outcrop-scale) fold and fault near Shamokin, Pa. ACD: June 1982.

A. A. DRAKE, JR., U.S. Geol. Survey, L. M. HALL, Univ. of Mass., and A. E. NELSON, U.S. Geol. Survey. Basement and Basement-Cover Relation Map of the Appalachian Orogen. Map depicts rocks which were basement (Proterozoic Y and Z and some lower Paleozoic) during the Caledonian orogenic cycle and their relation to their cover (autochthonous, allochthonous-parautochthonous, highly allochthonous), their age and metamorphic state, and the date of their last major tectonism. ACD: Fall 1981.

R. T. FAILL, Pa. Geol. Survey. Tectonic Map of Pa. Delineation of anticlines, synclines, and faults; portrayal of all igneous rocks; basement contours; structure contours on top of Onondaga in Plateau; delineation of lithotectonic units; tectonic provinces and age of deformation; unconformities; major fracture orientations; metamorphic isograds; radiometric dates; earthquake epicenters; cross sections. ACD: Nov. 1981.

PETER GEISER, Univ. of Conn. and LDGO, and T. ENGELDEN, LDGO. Finite Strain, Strain Partitioning and Structural Analysis of the Central Appalachian Foreland [eastern Pa., Plateau, Valley and Ridge, and Great Valley]. Mapping of buried décollements using layer parallel shortening fabrics provides evidence of multiple episodes of thrusting with different transport directions. Strain partitioning in conjunction with paleogeothermetric techniques further aids in distinguishing the various deformations. ACD: 1984.

L. D. HARRIS, Project Chief, U.S. Geol. Survey. Structural Studies of Devonian Black Shale in the Appalachian Basin. A summary report of structural studies for the Devonian sequence of the Appalachian Basin will be completed and open-filed during FY 1981. An open-file report on Landsat lineaments in parts of Ohio, Pennsylvania, and New York is currently in review; this will be a comparison to Open-File Report 79-368 which covered parts of West Virginia, Kentucky, Ohio, and Virginia. ACD: Sept. 1981.

L. D. HARRIS, Project Chief, U.S. Geol. Survey. Thrust Plate Models of the Appalachian Orogen. Seismic reflection data from Staunton to near Richmond, Virginia, will be acquired in FY 1981. These data will be analyzed and interpreted, and the regional structure compiled. ACD: Continuing.

GEORGE LOSONSKY and A. M. JOHNSON, Univ. of Cincinnati. Formation of Spaced Cleavage [Shamokin, Pa.]. Mapping of an area with prominent spaced cleavage. ACD: June 1982.

H. A. POHN, Project Chief, U.S. Geol. Survey. Structural Studies of Allegheny Plateau Using Remote Sensing. Field mapping of obvious structural disruptions along the Allegheny Front in Pennsylvania will continue during FY 1981. These disruptions will be related to the structural history of the Appalachians. Lineament mapping of the Valley and Ridge and Allegheny Plateau provinces will also continue in order to identify target areas of structural complexity. ACD: Continuing.

R. SIMPSON, Project Chief, U.S. Geol. Survey. Northeast Regional Tectonics. During FY 1981 this project will continue to investigate correlations between the regional gravity field and patterns of seismicity in Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, and Ohio. Correlations already observed need to be examined in detail and explained in physical terms insofar as possible. Investigation of the state of isostasy in the study area may also shed some light on neotectonics and the state of stress in the crust. ACD: Continuing.

G. C. STEPHENS, George Washington Univ., and T. O. WRIGHT, National Science Foundation. Structure and Stratigraphy of the Martinsburg and Reedsville Formations in the Central Appalachians. ACD: 1983.

R. J. WOLD, Project Chief, U.S. Geol. Survey. Great Lakes Geology. Existing high-resolution seismic reflection data and their interpretations for Lake Erie will be assessed in FY 1981. Charts showing surficial geology and underlying near-surface structures in Lake Erie will be constructed. High-resolution seismic data from lakes and offshore areas will also be studied in order to identify possible fault-related features and to determine the possible mechanism for causing such features. ACD: Continuing.

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CLASSIC SOLE-MARKS IN DEVONIAN SEDIMENTS NEAR LOCK HAVEN, CLINTON COUNTY, PENNSYLVANIA

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Sole-marks are casts, raised positive features, generally thought to be related to turbidity current deposition and best can be seen preserved where there is interbedded sandstone and shale.

Sole-mark (Pettijohn and Potter, 1964) is a term used for a variety of mesocopic primary sedimentary rock depositional structures found on the underside of beds. Their orientation may tell current direction and is descriptive of the stratigraphic aspects of the structures.

The sole-marks (Figure 1) found in the Devonian shale in the area local residents refer to as Brewery Hollow one-half mile northwest of Lockport, Pennsylvania (Figure 2) across the Susquehanna River from Lock Haven, Pennsylvania are linguoid sole-markings (Hills, 1963). These classic sole-marks, also termed flow-casts or flute-casts, formed by differential movements (slumping) and the filling of scour marks by sediments moved by turbidity currents.

Figure 1: Linguiform (tongue-like) sole-marks; current flowed from left to right.

Figure 2: Topographic map showing location (x) of the sole-mark features.

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NEW RELEASES FROM THE U.S.G.S.

Earthquake History of Pennsylvania

A seismicity map showing the earthquake history of Pennsylvania, from 1737 to 1977, including known dates, locations and magnitudes of 84 earthquakes, is now available from the U.S. Geological Survey, Department of the Interior.

The USGS map contains a chronological list of reported felt earthquakes that occurred in the state prior to 1965, plus those events registering over 2.5 on the Richter Scale recorded between 1965 and 1977.

Since 1977, the USGS has received reports on 4 earthquakes strong enough to be felt in Pennsylvania. The most recently reported earthquake was a magnitude 3.7 event that occurred near Philadelphia on March 11, 1980.

Highlights of the earthquake history of Pennsylvania include:

The earliest recorded earthquake in Pennsylvania occurred on December 8, 1737, near Philadelphia; later it was assigned an intensity value of IV, a shock strong enough to be felt by many people indoors and outdoors by a few people. Most of Pennsylvania's earthquakes are recorded in terms of their intensity on the Modified Mercalli Intensity Scale (MM), which measures an earthquake's effects in a given area and is based on human observation of damage and other effects rather than on instrument readings. On this scale, a shock of intensity XII produces total destruction; an intensity-V event may break a few dishes or windows. In contrast, the Richter Scale is based on instrument readings of the amount of energy released by an earthquake. The 1906 San Francisco earthquake, for example, had a maximum intensity of XI and an estimated Richter magnitude of 8.3.

Pennsylvania has had 13 earthquakes that equaled or exceeded intensity V (strong enough to be felt by nearly everyone indoors and by many people outdoors) in its recorded history. Of those quakes, six were of intensity V, six were of intensity VI, and one was of intensity VII.

The greatest ground-shaking in the state occurred on February 21, 1954, during a quake centered near Wilkes Barre. The quake measured VII on the Mercalli Scale and caused damage estimated at $1 million in a five-block residential area of Wilkes Barre. Gas and water mains snapped, releasing dangerous methane gas. The quake caused general alarm in the harder-hit areas and made it difficult for

many persons to stand during the ground shaking. Three days later a second tremor, of intensity VI, occurred in the same area and caused further damage.

Other large earthquakes centered in the state include five intensity-VI quakes occurring on March 8, 1889, near York; on May 31, 1908, near Allentown; on July 15, 1938, near York; on January 7, 1954, about 35 miles southwest of Allentown; and on May 12, 1964, about 25 miles east of Harrisburg.

Of the larger cities within the state, Philadelphia has been shaken the most; it experienced 18 recorded earthquakes during the years covered by the map.

Multiple earthquakes have occurred during several of the years covered by the map: in 1780, there were four quakes; in 1885, there were three; and in 1954 there were twenty-seven.

The most recent earthquake shown on the map measured intensity V and occurred on December 8, 1972, in an area about 35 miles southeast of Harrisburg.

Copies of the 36- by 25-inch map, including marginal text and tables, titled "Seismicity Map of the State of Pennsylvania," by C. W. Stover, B. G. Reagor, and S. T. Algermissen, and published as USGS Miscellaneous Field Studies Map MF-1280, may be purchased for 75 cents each from the USGS Eastern Branch of Distribution, Maps Section, 1200 So. Eads St., Arlington, VA 22202. Orders must specify the map identification number (MF-1280, and include check payable to the U.S. Geological Survey.

Land Use In The Greater Pittsburgh Region

The Greater Pittsburgh Region Land Use and Land Cover map at a scale of one inch equals 2 miles shows in color on one sheet 12 classes of land use. The residential class has been subdivided into single-family and multi-family in order to gain a better distinction in new urban areas.

This map is an outgrowth of the heavy damage sustained by the six counties, Allegheny, Armstrong, Beaver, Butler, Washington, and Westmoreland, of the Greater Pittsburgh Region during Hurricane Agnes in June 1972. The land use and land cover inventory was compiled for local and regional planners as an aid in reducing possible future damage from a similar cause. Of course, the map has many other direct and indirect uses.

Land use as shown is an interpretation of high altitude color infrared aerial photographs acquired by NASA in March and September 1973.

Map I-1248, *Land Use and Land Cover in the Greater Pittsburgh Region, PA, 1973,* scale 1:125,000, by James R. Wray, is available for sale ($1.50) by the Branch of Distribution, U.S. Geological Survey, 1200 South Eads Street, Arlington, VA 22202.

Film On National Hazards

The U.S. Geological Survey has released a new film on natural hazards entitled "When the Earth Moves." This 26 minute color-sound motion picture describes such hazards as earthquakes, floods, and landslides and relates some of the methods now being practiced in the United States to avoid or lessen their destructive impact.

The film is available for short-term loan, free of charge, or may be purchased by writing to:

Modern Talking Picture Service, Inc.
5000 Park St., North
St. Petersburg, Florida 33709

SURVEY ANNOUNCEMENTS

CALEDONIA AND PINE GROVE FURNACE STATE PARKS PARK GUIDE 15

Caledonia and Pine Grove Furnace State Parks are both of geologic and historic interest. These parks are located at the sites of significant iron charcoal furnaces which were supplied by local iron ore deposits for 150 years. About 1764, iron ore was discovered at the base of the Tomstown Dolomite in Mountain Creek Valley, Cumberland County. With plenty of wood and water power available, Pine Grove Furnace soon began operation and contributed firearms to the soldiers of the Revolutionary War. About 1830, more iron ore deposits were discovered on the west side of South Mountain and Caledonia Furnace, Adams and Franklin Counties, began operating. Both furnaces prospered during the Civil War but the Caledonia ironworks was burned to the ground in 1863 when Confederate General Early passed through Cashtown Gap en route to Gettysburg. Pine Grove Furnace terminated its operations in 1893 when their primary ore pit flooded.

Today, both sites are state parks to be enjoyed for their past and their present. The primary ore pit that flooded at Pine Grove Furnace is now a recreational lake. Hiking trails can be followed at either park to the old ore pits and charcoal furnaces. The vista of Mountain Creek Valley from Pole Steeple overlook is particularly beautiful.

Park Guide 15, written by Denise W. Royer, has been recently released by the Survey. The guide discusses the rocks found in the parks and their history. The location and occurrence of the iron ore deposits are described and the history of the industry is summarized. Geologic features are discussed; the prominent faults which pass through the park areas and Pole Steeple, the quartzite promontory overlooking Mountain Creek Valley. This park guide is available at both of the park offices and the Geologic Survey's office in Harrisburg.

25 YEARS OF SERVICE CELEBRATED

Shirley Barner, Secretary to the State Geologist, was presented with a cake honoring the anniversary of her 25 years of service to the Commonwealth. Shirley started with the Geologic Survey July 9, 1956 and except for a short period when she was with the Dept. of Banking, she has been instrumental in assisting in administering the daily operations and public services of the Survey.

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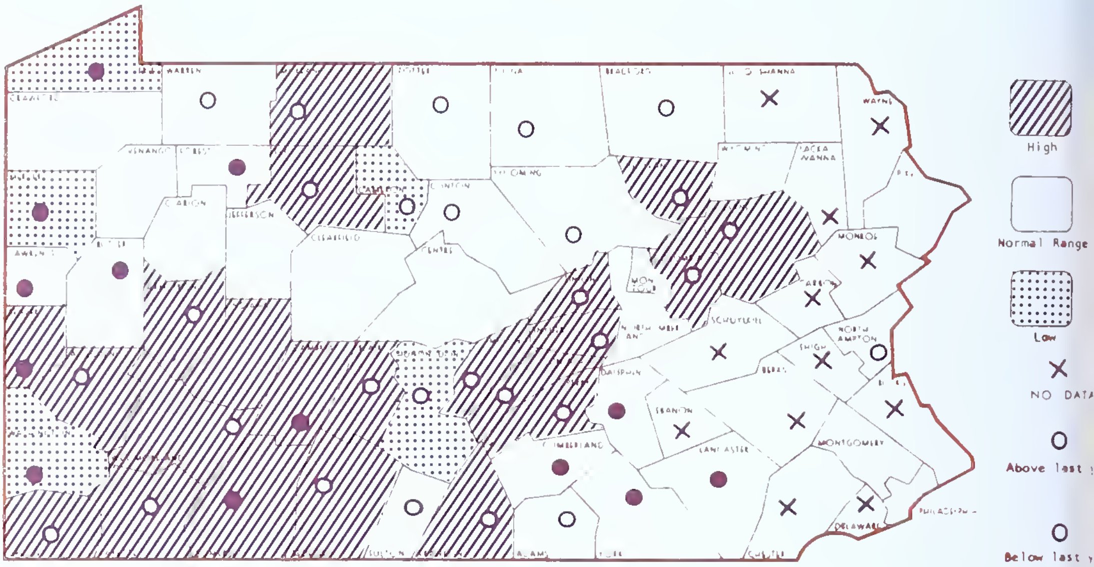
FOR

July 1981



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PENNSYLVANIA GEOLOGY

THE PENNSYLVANIA GEOLOGICAL SURVEY

COMMONWEALTH OF PENNSYLVANIA
Richard L. Thornburgh, Governor

DEPARTMENT OF ENVIRONMENTAL RESOURCES
Peter S. Duncan, Acting Secretary

OFFICE OF RESOURCES MANAGEMENT
Peter S. Duncan, Deputy Secretary

TOPOGRAPHIC AND GEOLOGICAL SURVEY
Arthur A. Socolow, State Geologist

CONTENTS

ON THE COVER: 176 feet high drilling rig located 20 miles north of Lock Haven, Clinton County, Pennsylvania. Aiming for a depth of 19,500 feet this jointly owned Texaco-Marathon well will be the second deepest ever drilled in Pennsylvania. Photo courtesy of Texaco.

PENNSYLVANIA GEOLOGY is published bimonthly by the Topographic and Geologic Survey, Pennsylvania Dept. of Environmental Resources, Harrisburg, Pennsylvania, 17120.

Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

OCTOBER 1981

FROM THE DESK
OF THE
STATE GEOLOGIST . . .

IT'S NOT OUR FAULT

We have been receiving numerous inquiries at the Pennsylvania Geologic Survey offices as to the extent and boundaries of the so-called "Eastern Overthrust Belt." I wish we knew!

The interest stems in part from the publicity given to the concept of such a geologic structure in eastern U.S. by such national media as the Wall Street Journal, New York Times, and Time Magazine. The public interest is enhanced by the significant new oil production being developed from the now proven "Western Overthrust Belt" of Idaho, Wyoming, and Montana. Thus, the questions we get are "where should we drill for the oil of the Eastern Overthrust Belt?" "How deep should I drill?" and "Does the Eastern Overthrust Belt extend under the granitic rocks of Berks and Chester Counties?"

The concept of an overthrust involves a large area in which a major portion of the earth's surface (referred to geologically as the *earth's crust*) has been subjected to a lateral push which caused one or more portions of the crust to slide up and over (or under) an adjacent portion — like two side-by-side cards being pushed together, with one sliding over the other. And geologically, there are places in the world when it is more like 3 or 4 cards being pushed over each other. The portion of the earth's crust which slid over the other actually slid along a flat (or nearly flat) surface of fracture known as a thrust fault.

About five years ago several innovative geologists utilized some new geophysical data from the southern Appalachian Mountain region as the basis for a concept that the eastern edge of the Appalachian region is an overthrust sheet which millions of years ago had been pushed westward as a thrust fault, resulting in a card-like "stacking" or doubling up of the earth's crust. As this concept attracted more and more believers amongst geologists, oil and gas geologists began to wonder if possibly there might be some of those resources in the lower slice of the crust, the portion which presumably was "over-ridden" and covered by the thrust faults. This has also resulted in oil and gas leasing in some of the eastern counties of Pennsylvania by both actual exploration companies and by speculators.

While some thrust fault features are already known to exist under the Appalachian Plateaus, as well as the Ridge and Valley province, they are not yet known to be of the magnitude envisaged in the concept of the larger Eastern Overthrust Belt. That concept remains yet to be tested and proved by the drilling of deep test holes, possibly as deep as 30,000 feet. It must be kept in mind that even if the new structural interpretation may be proved correct, there may be no oil or gas there.

Drilling of deep holes will be very costly (in the millions of dollars each), but drilling is the only positive way of determining if the new structural interpretation is correct, how wide an area is involved, and finally, if there are any oil and gas sources down there. Until those points are cleared up, to all who inquire we have to say candidly, we don't know the answer; the fault (concept) is not ours.

Arthur A. Socolow

DER MOVES TO IMPROVE OIL AND GAS-RELATED ENVIRONMENTAL PROTECTION

Due to rapidly rising prices for crude oil and natural gas in the past few years, there has been a tremendous increase in exploration and drilling for these energy resources in Pennsylvania.

In the past 12 months, nearly 2,500 new wells have been drilled and over 8,000 new drilling permits issued in Pennsylvania. This is double the rate of 3 years ago. And the outlook is for continued growth.

As is true in so many instances where there are large numbers of operators involved, and where there has been rapid expansion, there are some "rotten apples in the barrel." There have been many reports of oil and gas drilling and producing operations which have been harmful to our natural environment. In some instances the damage has been due to lack of adequate laws and regulations. In other cases the environmental violators have not been caught due to a lack of state manpower to inspect, catch, and prosecute.

Secretary Jones and DER have taken *two new courses of action* to correct the oil and gas related environmental problems.

First, the Secretary appointed an *Oil and Gas Environmental Advisory Committee* made up of equal numbers of environmental and industry representatives. That committee was assigned the task of reviewing existing DER procedures, laws, and regulations and to then recommend changes as deemed desirable to make DER a more effective agency for environmental protection.

Over the past 6 months, the Advisory Committee and its 3 subcommittees have met many times and labored diligently. They have now produced a draft amendment to the existing 1956 Oil and Gas Act; the draft amendment incorporates a large number of changes and additions to the original act. The principal ones being as follows:

1. Well operators will have to provide bond or other financial securities subject to forfeit if they damage and do not repair the environment.

2. Surface land owners will have to be notified of any planned drilling operations.
3. Minimum distances are specified between proposed wells and streams, bodies of water, and wetlands.
4. Minimum distances are specified between proposed wells and inhabited buildings.
5. The operators will pay a fee for each new well permit as issued.
6. Land which was disturbed at a well site will have to be restored according to set standards upon completion of the well.
7. Casing procedures are established to protect the quality of potable ground water.
8. Safety devices are required as necessary to prevent fires, blowouts, and explosions.
9. An oil and gas well plugging fund is established to pay for sealing abandoned wells.
10. Civil and criminal enforcement procedures and penalties are spelled out in case of operator failure to comply with the law.

It is anticipated that the above-listed changes, plus many others of a technical nature, will result in great improvement in the quality of oil and gas operations. It is especially encouraging that both the industry and environmental representatives are agreed as to the desirability of the proposed changes to the Oil and Gas Act.

The second major course of action taken by Secretary Jones and DER was to reorganize and streamline the oil and gas-related inspection and enforcement procedures in DER. Instead of being spread over 5 bureaus, the active inspection and enforcement will be handled by 2 bureaus: the Bureau of Topographic and Geologic Survey and the Bureau of Water Quality Management. These bureaus and their staffs will operate under a formally established set of policies and procedures, all of which will be officially coordinated by Dr. Arthur A. Socolow, State Geologist and Director of the Bureau of Topographic and Geologic Survey.

The field inspection staff of the 2 responsible bureaus will be increased by 13 new positions so as to enable the inspection staff to inspect a larger number of the oil and gas operations (particularly those reputed to be violators) as well as to revisit operations which have been ordered to take corrective action.

All staff members engaged in oil and gas well inspection and regulation will be cross-trained in all of the laws and regulations pertaining to oil and gas wells, and also as to the legal, technical, and mechanical procedures needed to correct violations.

The DER staff will also engage in training and educational programs for oil and gas industry operators with the aim of preventing problems and violations.

In carrying out the streamlined, reorganized procedures, the 2 responsible bureaus and the official coordinator will establish communication and coordination with all other related DER bureaus, namely, Soil and Water Conservation, Dams and Waterways Management, and Solid Waste Management. In addition, close working relations will be maintained with the Pennsylvania Fish Commission.

The Department of Environmental Resources is convinced that the steps being taken constitute a constructive move toward an important goal: To have the great industrial and economic benefits of Pennsylvania's important oil and gas energy resources, while still protecting the quality and integrity of our unique natural environment.

SECOND DEEPEST WILDCAT WELL IN PENNSYLVANIA HISTORY UNDERWAY

Texaco is drilling a wildcat well in north-central Pennsylvania that will be the second deepest in the state's history. The well is located in Clinton County, 20 miles north of Lock Haven, and will be drilled to a depth of 19,500 feet . . . almost 4 miles below the surface.

The well will test Cambro-Ordovician Formations on the edge of an area generally referred to as the Eastern Overthrust Belt. These formations are limestone layers deposited 450 - 500 million years ago. The well will cost $13.7 million and will take about a year to complete. State environmental inspections are being made on a weekly basis.

The drilling rig, owned by Loffland Brothers, was brought in from Oklahoma on 55 trucks. It was assembled on site and stands 176 feet tall. Drilling started on July 10th. The rig is manned by a crew of 15 men. They work in two, 12 hour shifts. Crew members work two weeks on and have two weeks off. They are flown in from New Iberia, Louisiana. All men live at the well site.

Texaco is the operator and holds a 50 percent interest in the well. Marathon Oil Company holds the other 50 percent.

LOOKING FOR AN OLD MAP?

Many people want maps that show an area of the United States as it existed many years ago. These are called historical maps, and there are two kinds:

Most commonly, historical maps are special maps, recently published, prepared by commercial firms to show such features as battlefields, military routes, or the paths taken by famous travelers. Typically, these maps are for sale to tourists at the site of historical events.

The other kind of historical map is the truly old map, one compiled by a surveyor or cartographer many years ago. Lewis and Clarke, for example, made maps of their journeys into the Northwest Territories in 1803-1806 and originals of some of those maps still exist.

Because there are many different kinds of old maps, stored in many different collections, they are difficult to research. However,

with a little imagination and a lot of perseverance, you can probably find just the map you want. There are many sources for you to investigate, ranging from historical societies to the cartographic offices of your State or local government to the National Archives and the Library of Congress.

The best place to begin a search for an old map is your local public or college library. As a first step, the reference librarian can help you make a list of historical associations in your State, using the *Directory of Historical Societies in the United States and Canada* (edited by Donna McDonald; published by the American Association for State and Local History, Nashville, Tennessee; 10th edition, 1975). Sometimes these groups have valuable collections; almost always they can suggest other places for you to look.

Another good source of information for the map-hunter is *Map Collections in the United States and Canada: A Directory* (compiled by David K. Carrington and Richard W. Stephenson; published by the Geography and Map Division of the Special Library Association, New York, N.Y.; 3rd edition, 1978). This also may be available through your library's reference desk.

The National Archives contain a large number of maps (Civil War maps, for example) compiled by Federal agencies. A leaflet entitled "Cartographic Records in the National Archives" lists a number of publications, many of them free of charge, that describe the map collections of the National Archives. If your library does not have a copy, you can order the leaflet (specify General Information Leaflet #26) from: Publication Sales Branch, National Archives, 8th and Pennsylvania Ave., N.W., Washington, D.C. 20408.

One publication described in the cartographic records leaflet is the "Guide to Cartographic Records in the National Archives." This publication contains comprehensive descriptions of the National Archives Map collections, including record group (file) numbers. It was designed to be especially useful to librarians, historians, and other professional researchers. If the guide is not in your local library, you can order a copy from: The Superintendent of Documents, U.S. Government Printing Office, Washington. D.C. 20402.

The Geography and Map Division of the Library of Congress has one of the world's great collections of maps and atlases. There is no single, comprehensive catalog of the Library of Congress cartographic collection, but you can order two free pamphlets that will set you on the right research track. These are entitled "The Geography and Map Division" and "The Geograhy and Map Division List of Publications." Look for these in your library, or order copies from: The Geography and Map Division, Library of Congress, Washington, D.C. 20540.

Another helpful Library of Congress publication is "The Geography and Map Division: A Guide to its Collections and Services." This publication goes into considerable detail about noteworthy items in the Library of Congress collection. It is available from the U.S. Government Printing Office (see address for Superintendent of Documents) at a cost of $1.15. Specify stock number 030-004-00015-9.

A large number of historical topographic maps dating from 1879 on are contained in the reference holdings of the U.S. Geological Survey. If you are interested in obtaining a photographic reproduction of a particular map, please describe the map as completely as you can; include your name, address, organizational affiliation, and telephone number, and send to: National Cartographic Information Center-East, U.S. Geological Survey, 536 National Center, Reston, Virginia 22092, telephone: 703-860-6336.

This article is condensed from a brochure titled "Looking for an old map" prepared by and available from The National Cartographic Information Center-East at the above address.

A HUMOROUS APPROACH TO LEARNING GEOLOGIC VOCABULARY

by Diane Baclawski

(adopted from May, 1980, issue of Journal of Geologic Education)

Which mineral is always hungry?	Apatite
Which rock is cleaner than dirt?	Soapstone
Which music group is the favorite of geologists?	Rolling Stones
What do you get when you scare a tree?	Petrified wood
What rock is worn by Irish geoiogists?	Greenstone
Where do geologists sleep?	On bedrock
How does a geologist buy his milk?	In quartz
Where do marine geologists go to relax?	An offshore bar
Which mineral does a geologist put in a martini?	Olivine
Who is the geologist's favorite actor?	Rock Hudson
What does a geologist use to cool off?	An alluvial fan
What does one geologist say to another?	Have a gneiss day

The Fossiliferous Stoney Brook Beds (Upper Devonian) of Columbia County, Pennsylvania

by Jon D. Inners
Pennsylvania Geological Survey

Approximately 400 feet below the top of the Upper Devonian Trimmers Rock Formation in central Columbia County is a 50- to 75-ft-thick interval of highly fossiliferous siltstones and shales that contains a distinctive fauna abounding in rhynchonellid, productid, and spiriferid brachiopods. In his early reconnaissance survey of the North Branch, Susquehanna River valley, I. C. White recognized the wide areal extent of this stratigraphic horizon and named it "the Stony Brook beds" from exposures at the mouth of Stony Brook (a deeply incised tributary of Fishing Creek) about 4 miles north of Bloomsburg (White, 1883, p. 71-72). Recent field work in the Bloomsburg, Mifflinville and Catawissa quadrangles (Inners, in press) has reaffirmed the utility of the Stony Brook as a mapping unit and has led to the unearthing of several good fossil collecting localities. It has also served as a basis for speculation on environments of deposition in the upper Trimmers Rock Formation.

The Stony Brook beds are one of three important marker horizons in the dominantly marine lower Upper Devonian of central Columbia County; the other two markers are a quartzose conglomeratic sandstone about 50 feet below the top of the Trimmers Rock and a thin red bed at the base of the overlying Catskill Formation (Figure 1.) The Stony Brook horizon, the most persistent of the three, can be recognized at bedrock exposures throughout the area shown in Figure 2. The conglomeratic sandstone is most conspicuously developed to the north and west of Bloomsburg (J. H. Way, personal communication), whereas the red bed apparently is continuous only to the south and east.

Lithologically the Stony Brook beds consist of medium-dark-gray, light-olive-gray weathering, argillaceous to fine sandy siltstone and some interbedded silty clay shale. The siltstones, which range in thickness from 2 to 18 inches (averaging 4 to 6 inches), commonly exhibit fine planer or rippled laminations. Lenticular concentrations of fossils 2 to 3 inches thick occur in many siltstone beds; the shells may be concentrated at the top, in the middle, or at the bases of the sedimentary layers (Figure 3). These fossiliferous bands are

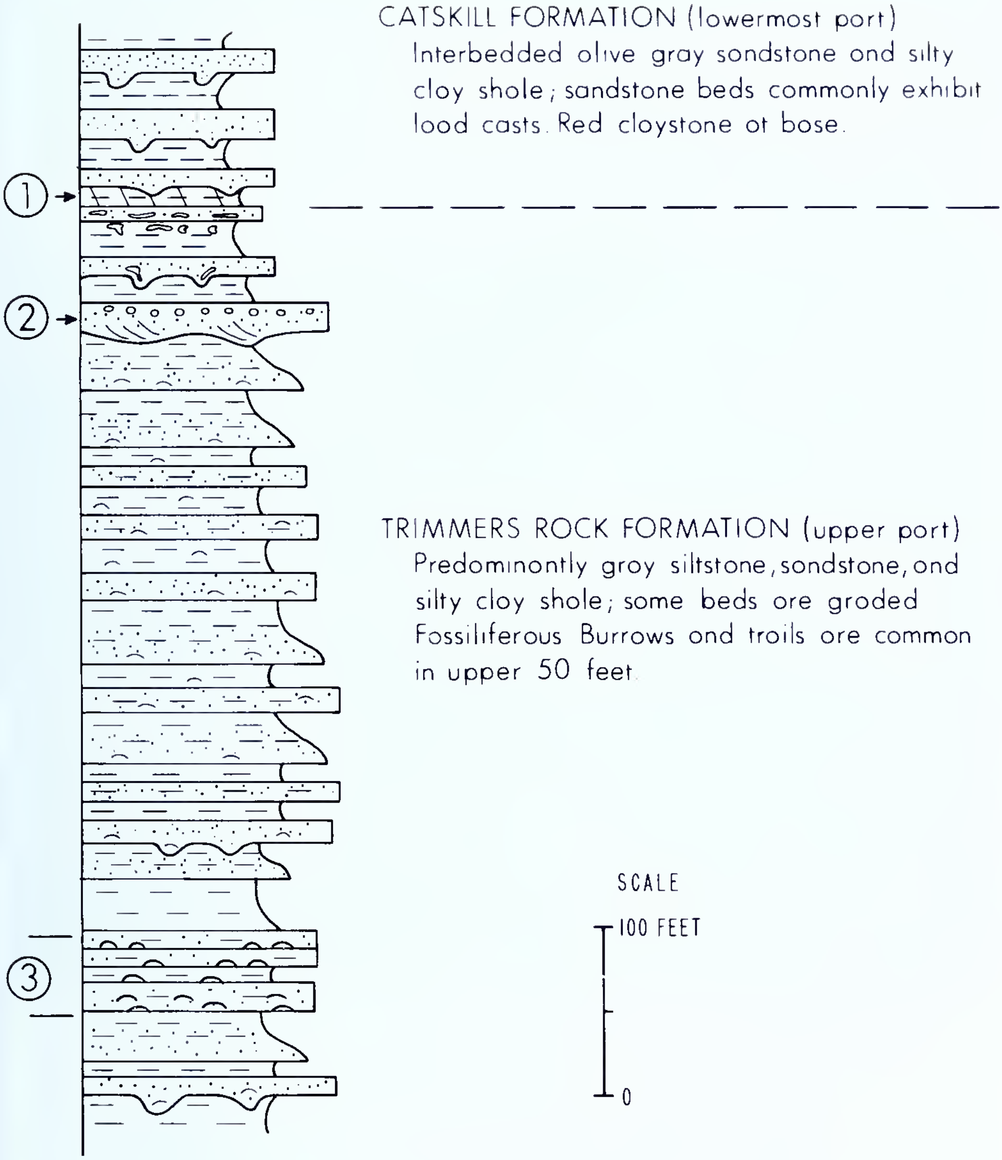

Figure 1. Stratigraphic markers in the lower Upper Devonian rocks of central Columbia County. (1 = red bed; 2 = conglomeratic sandstone; 3 = Stony Brook beds).

calcareous and contain original shell material in unweathered rock. Shale beds are generally one to several inches thick, chippy weathering, and sparsely to moderately fossiliferous.

Of the numerous localities where fossils can be collected in the Stony Brook beds, five are particularly notable for profusion of faunal remains. These are (Figure 2):

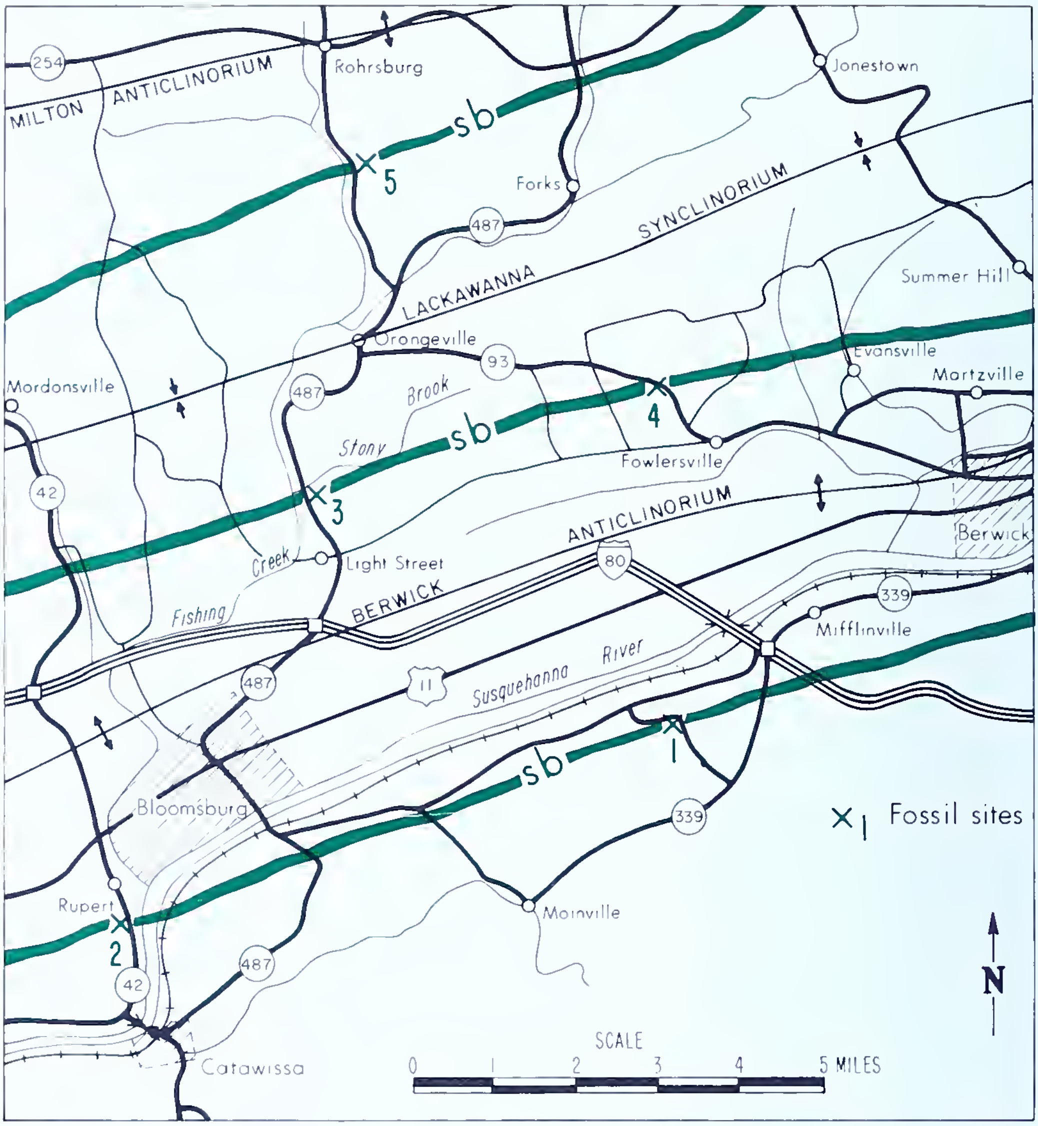

Figure 2. Outcrop pattern of Stony Brook beds (sb) and location of fossil collecting sites.

1. A borrow pit at a right angle bend in L.R. 19022, about 2.25 miles southwest of Mifflinville (41°00′30″N/76°20′17″W, Mifflinville quadrangle, Figure 4);
2. A road cut on the west side of Pa. Rte. 42, 0.5 mile south of Rupert (41°58′15″N/76°28′21″W, Catawissa quadrangle);
3. A road cut on L.R. 19033, Spur E No. 1, near its intersection with Pa. Rte. 487, on the south side of Stony Brook, about 1.1 miles north of Light Street—White's type locality (41°03′ 09″ N/76°25′42″W, Bloomsburg Quadrangle);
4. Ledges on the southwest side of Pa. Rte. 93, 1.1 miles north-northwest of Fowlersville (41°04′18″W/76°20′41″W, Mifflinville quadrangle);

5. A road cut on L.R. 19067 on the east side of Green Creek, 1.6 miles south of Rohrsburg (41°06′40″N/76°25′03″W, Bloomsburg quadrangle).

The first of these localities is especially appropriate for collecting because of its ease of access, freedom from traffic hazards, and

Figure 3. Fossiliferous siltstones of Stony Brook beds in borrow pit southwest of Mifflinville (Site 1). Arrows mark fossil concentrations. Hammer is 11 inches long.

abundance of loose material. It is also probably the most completely exposed section of the Stony Brook beds in the area.

The Stony Brook beds contain a moderately diverse fauna that abounds in the brachiopods *Leiorhynchus globuliforme* (Vanuxem), *Whidbornella hirsuta* Hall, and *Mucrospirifer posterus* (Hall and Clarke) (Figure 5). Countless specimens of these three species can be found at every exposure of the horizon. Also present, but much less common, are strophomenid brachiopods, bivalves, and cephalopods. The coquinoid bands in which the fossils occur generally consist of many shells of one of the three species named above and scattered shells of other types. The most favorable material for collecting consists of external and internal molds in fossiliferous bands leached of calcium carbonate.

Figure 4. Location map for Site 1, Mifflinville quadrangle.

A complete listing of the fossils collected by the writer from the Stony Brook beds is as follows (relative abundance shown by va = very abundant, a = abundant, c = common, unc = uncommon, and r = rare):

Brachiopods
- *Nervostrophia nervosa* (Hall) . . . . (r)
- *Schuchertella* sp. . . . . (r)
- *Whidbornella hirsuta* (Hall) . . . . (a)
- *Leiorhynchus globuliforme* (Vanuxem) . . . . (va)
- *Mucrospirifer posterus* (Hall and Clarke) . . . . (va)

Bivalves
- *Nuculoidea corbuliformis* (Hall and Whitfield) . . . . (c)
- *Palaeoneilo constricta* (Conrad) . . . . (unc)
- *Ptychopteria* sp. . . . . (r)
- *Lyriopecten* sp. . . . . (unc)

Cephalopods
- Unidentified orthocerids . . . . (r)

Crinoids
- Disarticulated columnals . . . . (unc)

Numerous specimens of these fossils have been entered into the Paleontologic Reference Collection of the Pennsylvania Geological Survey.

The Stony Brook beds were deposited in moderately deep (60 to 100 feet?) marine waters on the upper prodelta-outer delta platform of a prograding Upper Devonian delta complex (see Sutton and others, 1970). The fauna probably represents a life assemblage that has been slightly altered by local bottom currents. Evidence of significant post-mortem transport of shell material is lacking: e.g, most

specimens of *Leiorhynchus* consist of articulated shells, the alate wings of *Mucrospirifer* are generally intact, and impressions of spines can frequently be observed in the matrix surrounding *Whidbornella* specimens. Some current activity is clearly indicated, however, by the concentration of fossils into bands and by the ripple laminations that occur in many siltstone beds. The combination of profuse epifaunal, filter-feeding brachiopods and fairly common

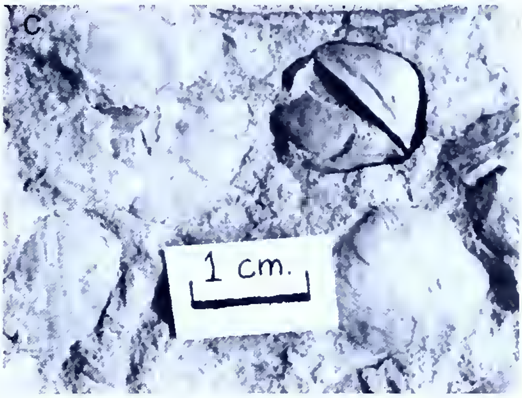

Figure 5. Typical weathered slab of fossiliferous siltstone from Stony Brook horizon, showing internal molds of *Leiorhynchus globuliforme* (a), *Whidbornella hirsuta* (b), and *Mucrospirifer posterus* (c). From Stoney Brook type locality north of Light Street (Site 3).

deposit-feeding, nuculoid bivalves also suggests current activity steady enough to supply abundant nutrients, but only intermittently able to significantly stir the bottom sediments.

Subsequent to the deposition of the Stony Brook beds, continued progradation of the delta across what is now Columbia County resulted first in the local development of delta-front sandbars (the conglomeratic sandstone marker in the upper Trimmers Rock) and later in the encroachment into the area from the southeast of a muddy, subaerial coastal fringe (the red bed marker at the base of the Catskill Formation) (Glaeser, 1974; Walker, 1972).

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SURVEY ANNOUNCEMENTS

GLACIAL DEPOSITS MAP

When the last ice sheet melted away from northeastern and northwestern Pennsylvania some 15,000 years ago, it left behind over the landscape a layer of loose rocks, sand, and gravel which had been carried by the moving ice.

The Pennsylvania Geological Survey has now issued a new, brightly colored page-size map of the state showing where the various glacial deposits are located, with an explanation of their characteristics and ages. The rock-stratigraphic terminology which geologists apply to the deposits is also presented. Included on this 9 x 12-inch map are the county boundaries and major drainage features of the state.

May 59, "Glacial Deposits of Pennsylvania" is available upon request from the Pennsylvania Geological Survey office in Harrisburg. It should be useful for classroom purposes as well as general public interest.

PENNSYLVANIA'S OIL AND GAS ANNUAL REPORT

Pennsylvania oil production in 1980 amounted to 2,940,187 barrels and natural gas production totaled 96,313 million cubic feet. Both of these figures represent increases in total production over 1979. Unfortunately, oil reserve estimates decreased by 1 percent, but this was offset by a 3 percent increase in natural gas reserves. These figures are surprising in light of the greatly increased activity in the Commonwealth during the year.

The total number of well permits issued during 1980 was 6,943, a 78% increase over 1979. However, 2,020 wells were actually reported drilled, representing a 4 percent increase over the previous year. Drilling for natural gas led the activity with 1,100 new wells reported during the year. The most active counties for gas wells drilling were Indiana, Erie, and Crawford Counties. A total of 777 new oil wells were drilled, with Venango, Warren, and McKean Counties leading oil well drilling activity. The remaining reported new wells included combination oil and gas wells (24), dry holes (55) and service wells (64).

These statistics, as well as information concerning drilling costs, leasing on state lands, geophysical activities, and summaries of regulatory functions (permitting, etc.) are included in the Bureau of

Topographic and Geologic Survey's new edition of the oil and gas annual report. The report is entitled "Oil and Gas Developments in Pennsylvania in 1980 with Ten Year Review and Forecast". The 97 page report was compiled by John Harper of the Oil and Gas Geology Division, with the assistance of the division's staff. Numerous maps, tables and graphs are included. The report also has a 17 page overview of drilling and production trends which occurred in the 1970's. This review summarizes the more important aspects of oil, shallow gas and deep gas ends with a suggestion of the possible trends for the 1980's.

Progress Report 194, "Oil and Gas Developments in Pennsylvania in 1980 with Ten Year Review and Forecast", is available from the State Book Store, P. O. Box 1365, Harrisburg, PA 17125. The price is $2.00 (plus 6% sales tax for Pennsylvania residents).

ORISKANY SANDSTONE IN THE SUBSURFACE OF PA.

What has traditionally been called the Oriskany sandstone in Pennsylvania actually includes two different sandstones, each in a different area. These are the Ridgeley sandstone and a basal Onondaga sandstone. These sandstones are described in the Pennsylvania Geological Survey's new report "Oriskany Sandstone in the Subsurface of Pennsylvania" authored by Kathleen D. Abel of the Pennsylvania Survey, and Louis Heyman of Gas Producing Enterprises.

The report includes four maps at a scale of 1:1,000,000 which show isopach contours of the Ridgeley and the total Oriskany sandstones, Oriskany production areas and depths to the Oriskany from the surface.

Oriskany (Ridgeley) production is related to both structural and stratigraphic-structural traps. A potential area for future Oriskany production is in Armstrong, Butler, and Lawrence Counties along the Ridgeley pinchout. Development of structural traps associated with subsurface overthrusting will also be important in the future. The thin, discontinuous Oriskany (basal Onondaga) sandstone in northwestern Pennsylvania is a possible secondary objective.

Mineral Resource Report 81, "Oriskany Sandstone in the Subsurface of Pennsylvania" is available from the State Book Store, P.O. Box 1365, Harrisburg, Pa. 17125. The price is $2.40 (plus 15¢ sales tax for Pa. residents). Check should be made payable to the Commonwealth of Pennsylvania.

GEOLOGY OF THE MONTOURSVILLE-HUNTERSVILLE AREA

"Geology and Mineral Resources of the Montoursville North and Huntersville [7½-minute] Quadrangles, Lycoming County, Pennsylvania," by cooperating geologists Richard B. Wells and Milena F.

Bucek has been published by the Bureau of Topographic and Geologic Survey. This new atlas report includes a detailed, full-color bedrock geologic map (1:24,000 scale) of a 120-square-mile area north and east of Williamsport. The bedrock units shown on this map include (in ascending order) the Old Port, Onondaga, Marcellus, Mahantango, Harrell, Brallier, Lock Haven, Catskill, Huntley Mountain, Burgoon, and Mauch Chunk Formations, and the Pottsville Group at the top. Details of structure are shown, and fracture traces visible on aerial photographs are plotted. A second full-color map delineates the distribution of nineteen separate glacial, periglacial, and post-glacial unconsolidated surficial deposits. A three-column explanation on each map gives a brief geologic description of each map unit, and summarizes the groundwater availability, engineering characteristics, and mineral resources of each unit.

A 68-page text gives a detailed discussion of the bedrock stratigraphy, surficial deposits, structural geology, environmental geology, and mineral resources. Type sections for the Muncy Till and Warrensville Till are included. This new atlas provides a detailed geologic base which will be useful for mineral-resource development, land-use planning, groundwater evaluations, waste-disposal management, and engineering studies. It will benefit local officials, planners, industry, conservationists, and residents of the Montoursville-Warrensville-Huntersville region.

Atlas 143cd is available for $13.10 (plus 6% sales tax for Pennsylvania residents) from the State Book Store, P. O. Box 1365, Harrisburg, PA 17125.

BASEMENT FAULTING REPORT NOW ON OPEN FILE

In recognition of the importance of the subject and the creative input by the author, a paper by Dr. Samuel I. Root, formerly with the Pennsylvania Geological Survey, on *Possible Recurrent Basement Faulting, Pennsylvania* has been placed on open file. The paper contains many new concepts and conclusions of regional and local significance. In view of the author's own introductory statement denoting this as "a speculative paper", the concepts and conclusions contained in the paper do not necessarily reflect the official interpretations of the Pennsylvania Geological Survey. Microfilm copies of this paper can be obtained free of charge by writing to: Pennsylvania Geological Survey, P.O. Box 2357, Harrisburg, Pa. 17120.

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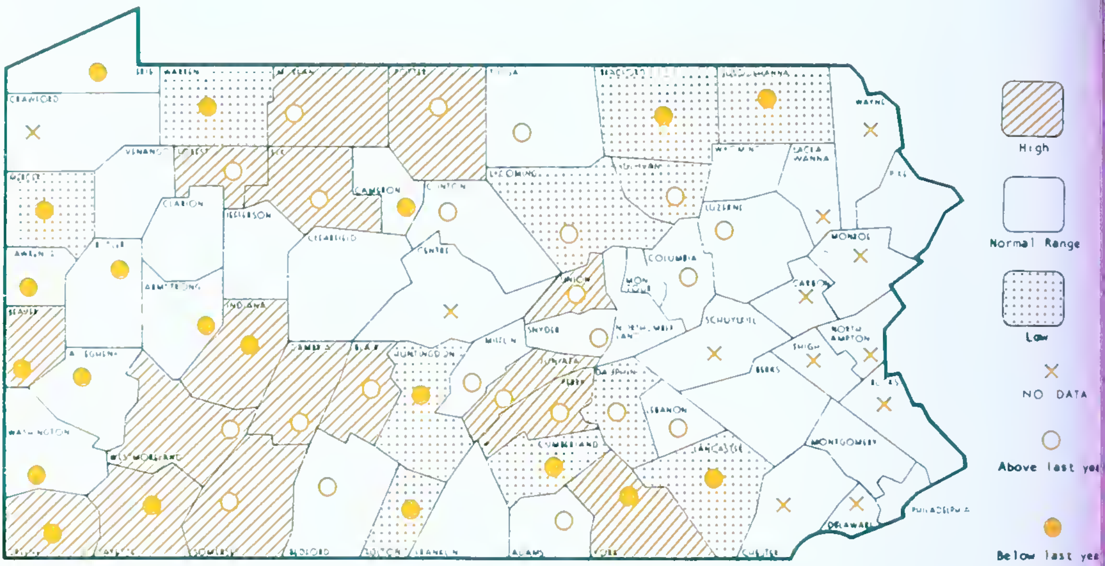
GROUND WATER LEVELS

FOR

October 1981



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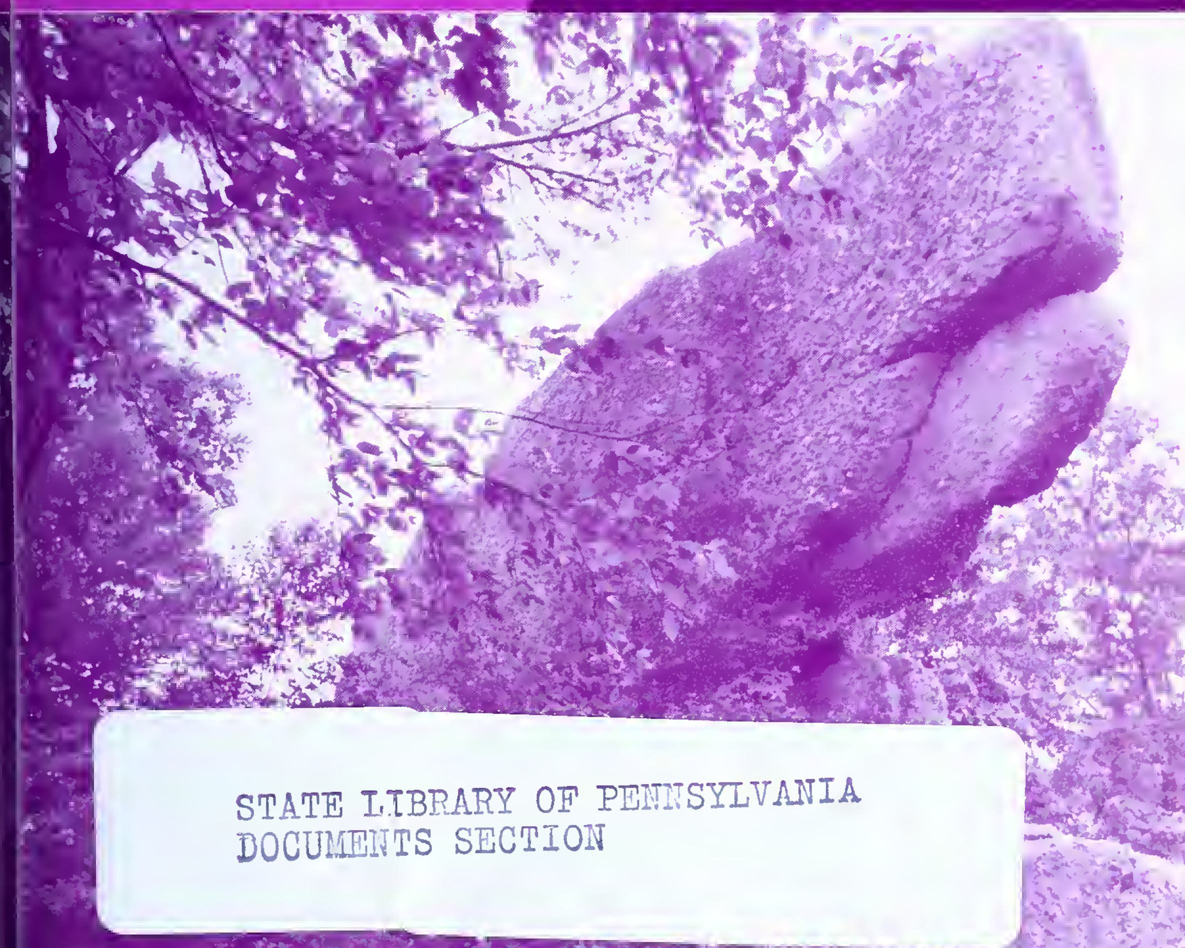

THE PENNSYLVANIA GEOLOGICAL SURVEY VOL. 12/6

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TOPOGRAPHIC AND GEOLOGICAL SURVEY
Arthur A. Socolow, State Geologist

CONTENTS

ON THE COVER: "Chinese Wall" as it is called, is an outcrop of Sharp Mountain quartz-pebble conglomerate (Pottsville Group, Pennsylvanian). Located in Cold Spring Township, Lebanon County, within Pennsylvania State Game Lands No. 211. Photo courtesy of William H. Bolles.

PENNSYLVANIA GEOLOGY is published bimonthly by the Topographic and Geologic Survey, Pennsylvania Dept. of Environmental Resources, Harrisburg, Pennsylvania, 17120.

Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

DECEMBER 1981

FROM THE DESK

OF THE

STATE GEOLOGIST . . .

SCIENCE PROGRAMS: BALANCING BENEFITS AND BUDGET

Recent pronouncements from such prestigious institutions as the National Academy of Sciences, the National Science Foundation, and the American Association for the Advancement of Science have all expressed concern that many basic and applied science research programs are being seriously jeopardized as a result of budget cutbacks at the national, state, and local government levels.

At a time of fiscal belt tightening, scientific programs will undoubtedly have to adjust to a share of the curtailment. But the concern in the scientific community is that in the absence of a large, vocal, public support group, the scientific programs may be asked to absorb more than a fair share of the cuts, and more than is safe for the national good.

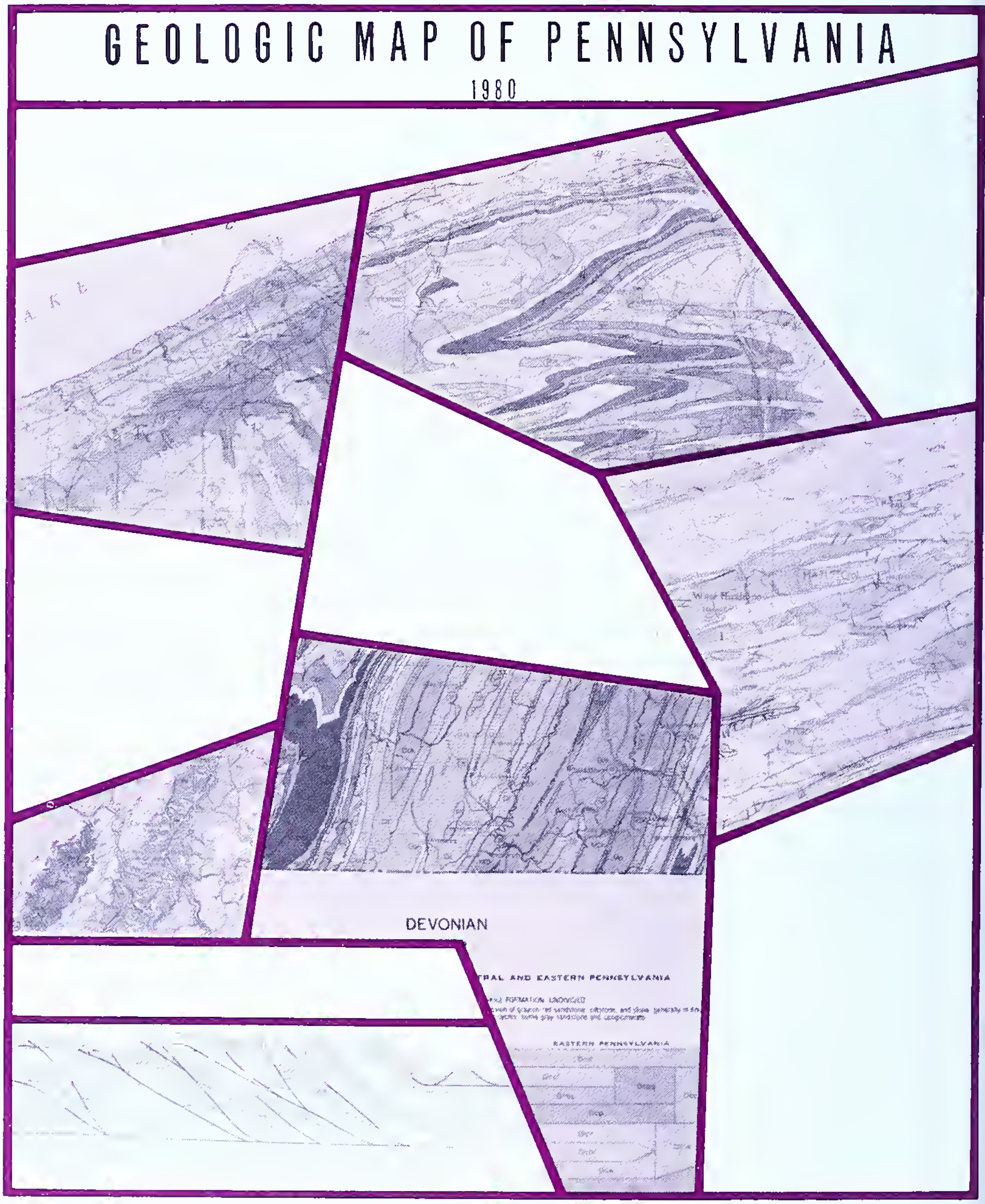
The national science groups which are beginning to speak up are pointing out that curtailment of today's science programs will inevitably result in serious handicaps to the economy and security of our nation tomorrow.

As geologists we have an awareness of how today's scientific investigations provide benefits and impacts to the state and nation tomorrow. We see this in energy resources and industrial raw materials which must be identified to keep our economy and our national defense strong; we see it in the research needed to define adequate water resources which we must have to sustain our homes, our agriculture, and our industries; and we see it in the careful studies needed to cope with problems of disposal sites for the massive quantities of municipal and industrial wastes.

When the public becomes aware of the significance of scientific programs to our nation's well being and to the nation's ability to compete economically and to mantain its security in the world, it will help to secure responsible and equitable budget support for the scientific programs of the nation and the states.

Arthur A. Socolow

A SPECTACULAR NEW



GEOLOGIC MAP OF PENNSYLVANIA

A new Geologic Map of Pennsylvania, completely revised and including all new geologic mapping to date, has been published by the Bureau of Topographic and Geologic Survey. This map replaces the edition of 1960 and represents the fourth update since the first geologic map of Pennsylvania was issued in 1858.

The new state geologic map is much more detailed then the 1960 edition and shows many more subdivisions of rock units. The 1960 map delineated approximately 130 geologic rock formations, whereas the new edition shows close to 200 geologic units. Among the other new features of the new map is an overprinted grid showing the boundaries (and names) of the 7-½ minute guadrangles; there is also an overprint (in purple) of the axes of the major synclinal and anticlinal fold structures of the Appalachian Plateau.

The new full-colored Geologic Map of Pennsylvania is published at a scale of 1:250,000 (one inch equals approximately four miles) and is printed on two sheets. When the two sheets are joined, the map measures 58 by 81 inches; a third sheet (29 by 42 inches) shows four interpretive geologic cross sections. The brilliant, contrasting colors used on the map not only help to accentuate the geologic "grain" of Pennsylvania, but also result in national acclaim of the map as a work of art.

The map was compiled under the supervision of T. M. Berg, Chief of the Geologic Mapping Division, and was edited by C. M. Dodge, Geologic Editor for the Survey. The compilers working with Berg included W. E. Edmunds, A. R. Geyer, A. D. Glover, D. M. Hoskins, D. B. MacLachlan, S. I. Root, W. D. Sevon, and A. A. Socolow. The cartographic work was done by J. G. Kuchinski. The entire project was conducted under the direction of State Geologist Arthur A. Socolow. The color separations and printing were done by the Williams and Heintz Map Corporation of Capitol Heights, Maryland.

Copies of the new map are available from the State Book Store, P.O. Box 1365, Harrisburg, PA 17125. The price of the map is $9.00 per copy (plus 6% sales tax if mailed to a Pennsylvania address). Checks should be made payable to *Commonwealth of Pennsylvania*. The map may be requested either rolled or folded. Folded copies will be sent unless rolled copies are specifically requested.

Changes in ground-water levels in the Susquehanna River Basin, October 1980—October 1981

By James M. Gerhart, U.S. Geological Survey and George J. Lazorchick, Susquehanna River Basin Commission

Water levels were measured in 322 wells in the Lower Susquehanna River Basin in Pennsylvania and Maryland during October 19-22, 1981 (see figure 1 for location). The measurements were made as part of a ground-water resource evaluation being conducted by the U.S. Geological Survey in cooperation with the Susquehanna River Basin Commission. This was the third measurement of water levels in these wells, the other two being in October 1980 and April 1981. October measurements generally represent annual low ground-water conditions while April measurements generally represent annual high ground-water conditions. With the three sets of measurements, it is possible to compare fall 1981 and spring 1981 ground-water conditions to fall 1980 conditions. Ground-water conditions in the fall of 1980 are of particular interest because below-normal precipitation in the fall and winter of 1980-1981 resulted in drought conditions which created many ground-water supply problems. A comparison between fall 1981 and fall 1980 water levels can be used to estimate the potential for similar drought conditions this winter.

In an article in this magazine in June 1981, the median water-level changes between October 1980 and April 1981 were reported. In nine of eleven counties in the lower basin, median water-level changes indicated various degrees of recovery; in the other two counties, the median water-level changes indicated continued decline. The data also indicated recovery in three physiographic sections and decline in one. The two counties and the one physiographic section showing no recovery of water levels were in the southeast part of the lower basin; the remaining counties and

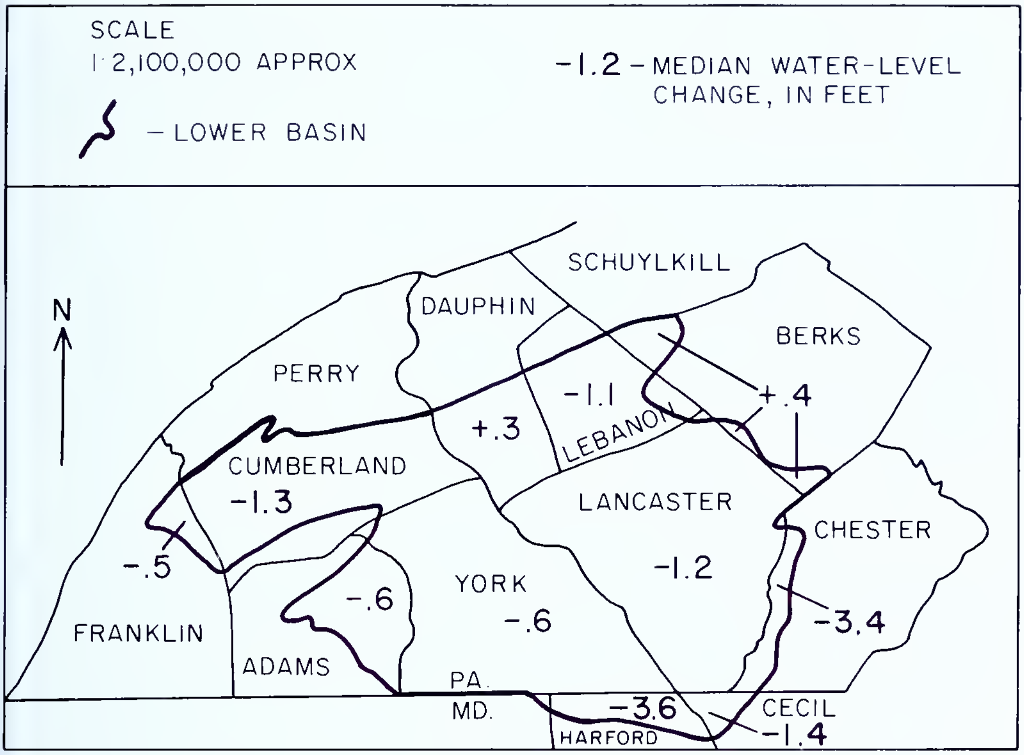


Figure 1. Median water-level changes, in feet, by county, for parts of counties in lower basin, for October, 1980-October, 1981.

physiographic sections showed a general increase in degree of recovery of water levels to the northwest. The exception to this trend occurred in the Triassic Lowland section and in those counties containing large areas of the Triassic Lowland section. Water levels there showed the greatest recovery in the lower basin.

The median water-level changes between April 1981 and October 1981 indicate declines in all eleven counties and four physiographic sections (table 1). The relative magnitudes of water-level decline follow the same trend as the degree of water-level recovery in the October 1980-April 1981 period. Declines in water level increase to the northwest, with the exception of the Triassic Lowland section and counties included therein which show the greatest water-level declines in the lower basin.

Median water-level changes from October 1980 to October 1981 indicate a net annual decline of water levels in nine of eleven counties and in all four physiographic sections. Figures 1 and 2 show these median water-level changes by county and physiographic section, respectively. Tables 2 and 3 contain summaries of the computed statistics by counties and physiographic sections, respectively.

Table 1. Water-level changes, in feet, by county and physiographic section, comparing April 1981 and October 1981.

County	*Median*	*Physiographic Section*	*Median*
Adams	– 6.4	Great Valley	– 4.4
Berks	– 4.6	Triassic Lowland	– 5.1
Cecil (Md.)	– 2.2	Conestoga Valley	– 2.8
Chester	– 1.0	Piedmont Upland	– 1.9
Cumberland	– 5.2		
Dauphin	– 2.4		
Franklin	– 4.3		
Harford (Md.)	– 1.9		
Lancaster	– 2.3		
Lebanon	– 5.2		
York	– 3.6		

The two counties with the greatest net water-level declines are Chester and Harford, the counties which showed no recovery of water levels between October 1980 and April 1981 (figure 1). Berks and Dauphin Counties show slight recoveries of water levels. The other seven counties show net declines ranging up to about 1.5 feet.

In figure 2, the Piedmont Upland section shows the greatest net decline of water levels; this physiographic section also showed a water-level decline between October 1980 and April 1981. The Triassic Lowland section shows essentially no net change in water levels. The remaining two physiographic sections show net water-level declines of about 1 foot.

Table 2 shows the range of water-level changes and the percent of wells with net declines in each county. These data can be used in conjunction with the median water-level changes to describe the ground-water conditions in each county. Cumberland, Dauphin, Lebanon, Lancaster, Franklin, and York Counties all have some wells in which water levels declined over 10 feet during the period, with Cumberland County having some wells in which over 20 feet of decline was observed. In Harford, Cumberland, Franklin, Chester, and Lancaster Counties, about 80 percent of the measured water levels showed a decline over the period.

The statistics for water-level change by physiographic section between October 1980 and October 1981 are shown in table 3. All four physiographic sections have some wells that experienced over 10 feet of water-level decline; some water levels in the Great Valley section show over 20 feet of decline. Slightly more than half of the measured water levels in the Triassic Lowland section were below those of the previous fall. About 75 to 80 percent of the measured water levels in the other three physiographic sections were lower than those in the fall of 1980.

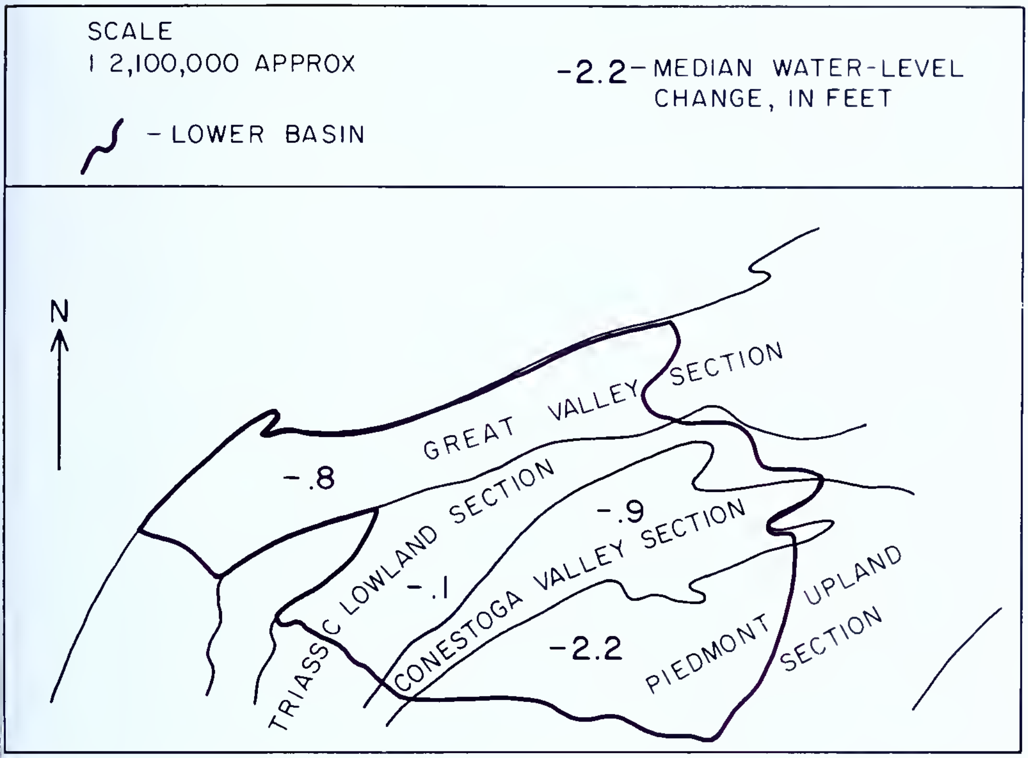


Figure 2. Median water-level changes, in feet, by physiographic section, for parts of sections in lower basin, for October, 1980-October, 1981.

Table 2. Water-level changes, in feet, by county, comparing October, 1980 and October 1981.

County	*Number of wells*	*Median*	*Range high*	*Range low*	*Percent of wells showing decline*
Adams	20	− .6	4.7	− 1.5	60
Berks	6	+ .4	2.9	− 2.3	33
Cecil (Md.)	6	− 1.4	2.7	− 4.9	67
Chester	5	− 3.4	4.3	− 4.4	80
Cumberland	36	− 1.3	2.3	− 21.5	83
Dauphin	15	+ .3	16.2	− 19.5	47
Franklin	6	− .5	.1	− 11.8	83
Harford (Md.)	15	− 3.6	2.7	− 7.4	87
Lancaster	101	− 1.2	13.3	− 12.3	79
Lebanon	31	− 1.1	2.0	− 14.1	71
York	81	− .6	12.4	− 10.9	68

Table 3. Water-level changes, in feet, by physiographic section, comparing October, 1980 and October, 1981.

Physiographic section	*Number of wells*	*Median*	*Range high*	*Range low*	*Percent of wells showing decline*
Great Valley	80	– .8	16.2	– 21.5	76
Triassic Lowland	72	– .1	10.3	– 13.3	56
Conestoga Valley	89	– .9	6.6	– 12.3	80
Piedmont Upland	81	– 2.2	13.3	– 10.9	77

The fall of 1980 and the winter of 1980-1981 were seasons of below-normal precipitation in the lower basin. Ground-water levels declined over these seasons and approached water levels observed during the drought of the early 1960's. Spring 1981 precipitation was near normal, but as the June 1981 article in this magazine showed, precipitation was not great enough to replenish the ground-water system in parts of the lower basin. Since most ground-water levels in the lower basin are at or below last fall's levels, below-normal precipitation again this fall and winter could result in water-supply problems of equal or greater magnitude than those of last year.

U.S.G.S. INCREASES MAP PRICES

Prices for U.S. Geological Survey maps have been increased. The 1:24,000 quadrangle topographic maps will now sell for $2.00 each. The 1:50,000 county topographic maps are now priced at $3.25 per sheet. Other thematic maps have also increased in price. To obtain current price information and to order maps contact:
Eastern Region-Map Distribution
U.S. Geological Survey
1200 South Eads Street
Arlington, VA 22202

CORRECTION

The price listed for Mineral Resource Report 81, "Oriskany Sandstone in the Subsurface of Pennsylvania" in the October, 1981 issue of Pennsylvania Geology is incorrect. The correct price is $3.65 plus 6% sales tax for Pa. residents.

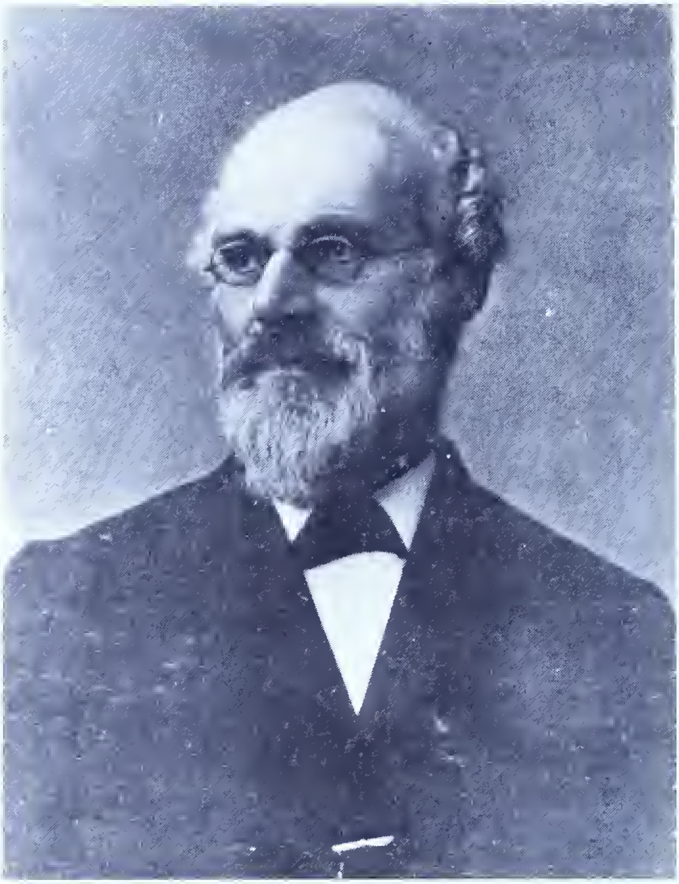
EDWARD WALLER CLAYPOLE -- CENTENNIAL

by Emily Giffin
Whitefish Bay, WIS

The last century has seen the development of the discipline of geology from a subunit of "natural history" to a broad subject encompassing fields as diverse as geophysics, comparative planetology and paleontology. Often preoccupied with our own isolated specialties, a look backward can remind us of the amazing breadth of early researchers. Such reflection is especially rewarding in a state which, like Pennsylvania, has a rich geological history. It is also particularly appropriate in 1981 to recognize one of Pennsylvania's early distinguished geologists on the centennial of his arrival in the state. Now, 100 years later, his geologic work in Perry County stands as a model of geologic mapping skills.

Edward Waller Claypole (1835-1901) was born in Herfordshire, England, the son of a Baptist clergyman. His strict early education was largely home-taught, and concentrated on the classics. He later took formal bachelor's degrees in the arts and sciences from the University of London in 1862 and 1864. In 1866 he was appointed a tutor in Classics and Mathematics at Stokescroft College in Bristol, a Baptist college. Here the controversy raging around the recent (1859) publication of Darwin's theory of evolution by natural selection touched his life. Forced to renounce evolution as heretical to the Baptist tenets of the school or lose his post, he chose the latter. This act was a decisive break with his upbringing, and left him, recently widowed with three children, without means of support. Forced to leave the existing academic climate in England, he emigrated, arriving in the United States in October, 1872.

Here, despite various personal problems, Claypole began a distinguished academic career. For eight years (1873-1881) he taught natural history at Antioch College in Yellow Springs, Ohio. There he concentrated on the nature of the preglacial surface of the Great Lakes area. He also published on such diverse topics as "Life History of the Buckeye Stem Borer," an "Upper Silurian Tree," and "Migration of Plants from Europe to America." When Antioch temporarily closed in 1881 with funding difficulties, Claypole left for the Pennsylvania Geological Survey.



EWClaypole
8-5-88

Fig. 1. Edward Waller Claypole (1835-1901).

As a geologist for the Second Geological Survey under J. P. Lesley, Claypole was assigned Perry and Juniata counties as his field area. Working primarily in Perry County, he was extremely successful in recognizing the presence and absence of the classic units of the New York sequence. Within unit No. V of the First Pennsylvania Survey he recognized Onondaga as well as Clinton rocks. He also demonstrated the absence of Niagaran and Corniferous rocks in the county by the lack of their distinctive fossil fauna. Rocks previously identified as Corniferous he assigned to the Marcellus Formation of the Hamilton Group. The existence of the Perry County and Little

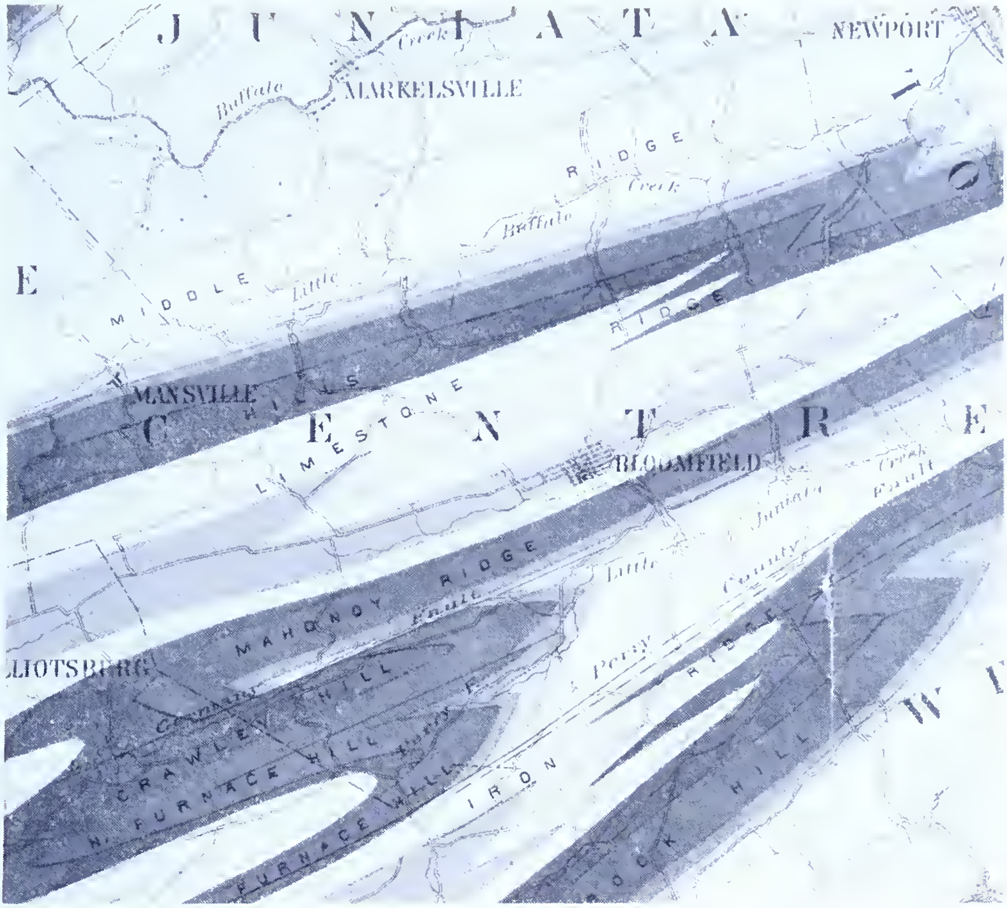


Fig. 2. Part of Claypole's revised geologic map of Perry County, showing the Perry County Fault.

Germany faults were recognized on the basis of the excessive thickness of the Hamilton beds in the Mahanoy Ridge area and the contiguous occurrence of fossil faunas usually separated by a thick stratigraphic sequence. These and other findings were published in volume F2 of the Second Survey, accompanied by a revision of the geological map of Perry County.

Claypole's most notable contributions during his short two-year stay in Pennsylvania were, however, in the field of paleontology. His careful stratigraphic collections were documented in the second volume of his Perry County study (never published), in his additions to the Dictionary of Paleontology (P4), and in the Catalogue (O3) of the Second Survey fossil collections, recently curated and now housed at the William Penn Memorial Museum. His most famous collection was that of Silurian fish. He described *Palaeaspis (Americaspis)*, which was at its discovery the world's oldest known fish,

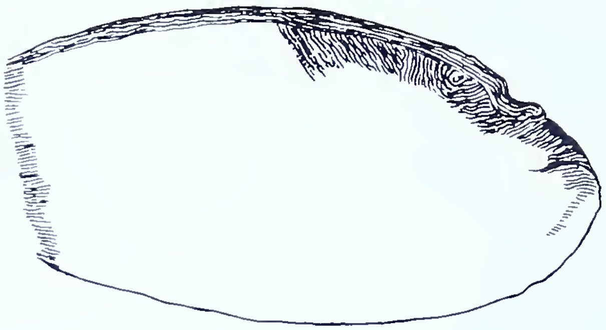


Fig. 3. The dorsal shield of *Palaeaspis (Americaspis) americana* as described by E. W. Claypole in 1885.

from the Bloomfield Sandstone (Wills Creek Formation) of Perry County. He carefully documented its Silurian age by stratigraphic reasoning and its vertebrate identification by hand ground thin-sections that demonstrated its bony structure. He also described an ?acanthodian spine from the Rose Hill Formation, which still stands as the oldest known fragment of a jawed vertebrate.

When the Pennsylvania legislature restricted Survey funds in 1883, Claypole moved on, this time to newly-established Buchtel College in Akron, Ohio. There he continued to publish on his Pennsylvania field work for several years. While at Buchtel he submitted his original work on the geology of Pennsylvania and Ohio to the University of London, and in 1888 he returned temporarily to England to receive the degree of Doctor of Science. During this same time, he was a founder of the journal *American Geologist,* which he also served as editor.

Fig. 4. *Onchus clintoni,* the ?acanthodian spine described from the Rose Hill Formation of Perry County by E. W. Claypole.

Claypole stayed at Buchtel College for fifteen years, publishing on a wide variety of topics. In the 1890s his papers concentrate on the Devonian placoderms and sharks of Ohio, as well as Pleistocene studies. In 1898 he moved again, this time to the Throop Institute (now California Institute of Technology) in Pasadena, for health reasons. His last papers dealt with the geology of California. Claypole died in Long Beach, California in 1901.

In addition to an extensive publishing career, Claypole was engaged during almost his entire adult life as a teacher. He taught not only geology, but zoology, botany, and Latin. He was an innovative instructor in a time of dry memorization, for which he was criticized. Nevertheless, he remained dedicated to a more practical view of life and education, much to the delight of his students.

Even after 100 years, the breadth and excellence of Edward Waller Claypole's work serves as an inspiration to those who love nature and seek to understand it.

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SURVEY ANNOUNCEMENTS

REPORT ON THE MEDINA GROUP

The Pennsylvania Geological Survey has recently published a report on the Medina Group in the subsurface of northwestern Pennsylvania. The report, entitled "Geology and Natural Gas Production of the Lower Silurian Medina Group and Equivalent Rock Units in Pennsylvania", was written by Robert G. Piotrowski, formerly of the Survey's Oil and Gas Geology Division. The Medina Group was classified as a tight formation in September, 1981, by the Federal Energy Regulatory Commission, allowing gas well operators to receive peak prices for their product. This incentive has stimulated exploration and development of the Medina as a natural gas reservoir in

Erie, Crawford, Mercer, Venango, and Warren Counties. As such, this report should be of particular interest to those active in the Medina fields.

The report, which includes a short text and 11 plates, details the structure, stratigraphy and depositional framework of the Medina Group, and its relationship to the Tuscarora Sandstone and Shawangunk Conglomerate of central and eastern Pennsylvania. The plates include isopach, lithofacies, structure, drilling depth and field outline maps which are discussed in the text.

Mineral Resources Report 82, Geology and Natural Gas Production of the Lower Silurian Medina Group and Equivalent Rock Units in Pennsylvania, is available for $6.20 (plus 6% sales tax for Pa. residents) from the State Book Store, P.O. Box 1365, Harrisburg, PA 17125.

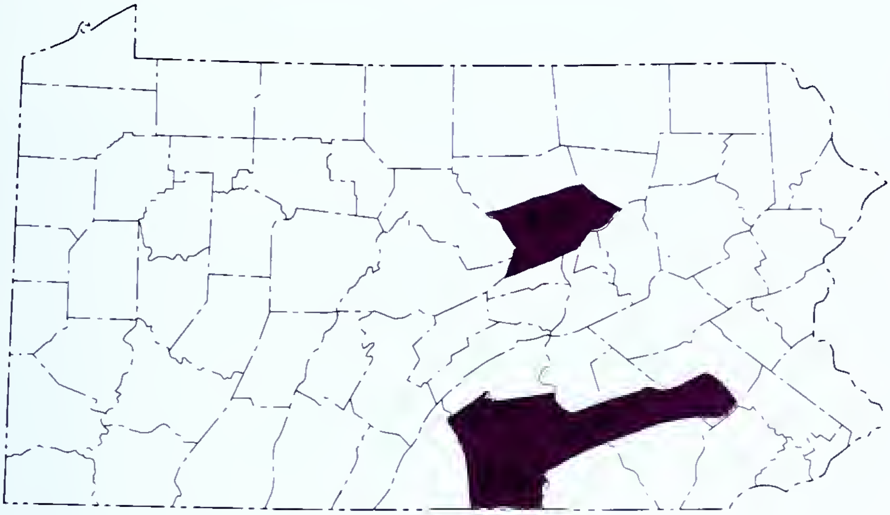
REPORT ON THE HUNTLEY MOUNTAIN FORMATION

When the new state geologic map of Pennsylvania was being prepared, it was recognized that a discrete succession of nonmarine strata in the north-central part of the Commonwealth had traditionally carried names that had some time significance. Specifically, a line had been drawn on older maps that was in effect, the presumed boundary between Mississippian and Devonian rocks. The strata above and below that presumed line are nearly identical, and in fact constitute a transitional succession between the underlying Devonian Catskill Formation and the overlying Mississippian Burgoon Sandstone. This 650-ft-thick sequence of greenish-gray to light-olive-gray flaggy sandstone having minor grayish-red shale beds has been named the Huntley Mountain Formation. The type section is at Huntley Mountain just north of Waterville, Pennsylvania. The new formation has been traced from Centre and Clearfield Counties northward through Cameron and Potter Counties, and eastward from Clinton and Lycoming Counties through Tioga, Sullivan, Bradford, and Wyoming Counties.

The new formation is defined and described in detail in Information Circular 83 authored by Thomas M. Berg and William E. Edmunds, and is titled: *The Huntley Mountain Formation: Catskill-to-Burgoon Transition in North-central Pennsylvania*. This publication of the Bureau of Topographic and Geologic Survey is available from the State Book Store, P.O. Box 1365, Harrisburg, PA 17125. The price is $2.75 (plus 6% sales tax for Pennsylvania residents).

NEW GROUNDWATER REPORTS PUBLISHED—SURVEY ATTACKS THE DROUGHT

With the 1980-1981 drought in eastern Pennsylvania still continuing, the Survey announces the release of four "key" comprehensive groundwater reports. Throughout the eastern part of the state the need is great and every effort is being made to meet that need. This timely release of four publications that will aid all those seeking private and public groundwater supplies is an outgrowth of the Survey's increased effort to study Pennsylvania's groundwater resources.



W-49, *The Groundwater Resources of the Gettysburg and Hammer Creek Formation, Southeastern Pennsylvania*, written by C. R. Wood, includes portions of Berks, Lancaster, Lebanon, Dauphin, York and Adams counties. These important aquifers of southeastern Pennsylvania are capable of yielding large quantities of groundwater for public, industry, and private water supplies. This report with a full-color map shows where these high groundwater yields may be expected, optimum depths to drill, and an indication of the groundwater quality to be expected.

W-50, *The Groundwater and Geology of the Cumberland Valley, Cumberland County, Pennsylvania*, by A. E. Becher and S. I. Root, describes the limestone and shale aquifers of the Valley. The extremely high groundwater yields of certain limestone formations in the Valley make this an important publication for anyone planning to drill for a water supply. By use of the full-color map, text, and well-tables in this report, it is possible to select the best site for a high-yield well.

W-51, *The Groundwater Resources of the Williamsport Region, Lycoming County, Pennsylvania*, by O. B. Lloyd, Jr. and L. D. Carswell, includes an evaluation of all the unconsolidated and rock units of southern Lycoming County. Among these aquifers is the important, extremely high-yielding sand and gravel aquifer along the Susquehanna River. Large industrial and public water supplies are available from this formation. Equally important is the quality of the groundwater in this aquifer and a thorough analysis of this quality concern is given.

W-52, *Summary Groundwater Resources of Adams County, Pennsylvania*, written by L. E. Taylor and D. W. Royer, gives an overview of the groundwater availability of every rock unit in the county. This report is another of the Survey's series of county groundwater summary reports. Eventually all 67 counties of Pennsylvania will be studied. A full-color geologic and groundwater availability map is included. Hundreds of wells are plotted on the map and a well-table provides the reader with specific groundwater and well characteristics.

Wherever possible the maps included with these reports are to a scale of 1.25 inches equals a mile. The topographic and culture base is that of the Survey's new county topographic maps. Each of these reports is available at the following cost: Bulletin W-49 @ $9.60; W-50 @ $10.60; W-51 @ $8.50; W-52 @ $10.70. Residents of Pennsylvania must include 6% state sales tax. All publications are available from the Department of General Services, State Book Store, P.O. Box 1365, Harrisburg, PA 17125.

REPORT ON SHALES AND CLAYS OF PA

The Bureau of Topographic and Geologic Survey announces the publication of Mineral Resource Report 79, *Properties and Uses of Shales and Clays, South-central Pennslyvania*, by Bernard J. O'Neill, Jr., and John H. Barnes. This report contains data on 143 samples of shales and clays from 10 counties (Bedford, Blair, Centre, Fulton, Huntingdon, Juniata, Mifflin, Perry, Snyder, and Union). Included are unfired properties, fired properties, major- and minor-oxide content, and approximate mineralogic composition.

M-79 is available for $5.60 from the Department of General Services, State Book Store, P.O. Box 1365, Harrisburg, PA 15125.

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In Cooperation with The U.S. Geological Survey

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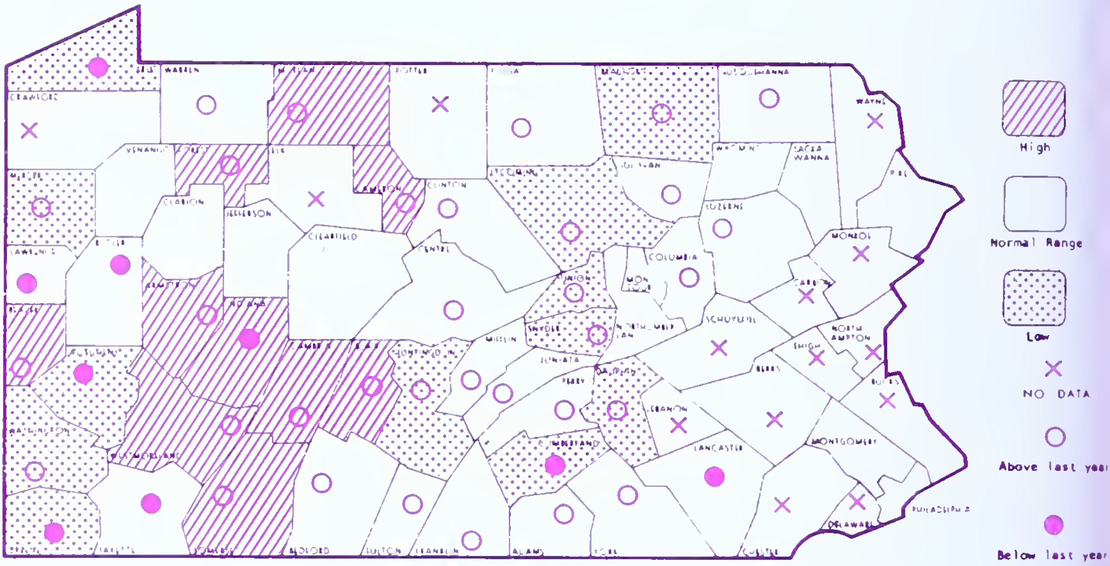
In Cooperation with The U.S. Geological Survey

GROUND WATER LEVELS

FOR

November 1981



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PENNSYLVANIA GEOLOGY

THE PENNSYLVANIA GEOLOGICAL SURVEY VOL. 13 NO. 1

COMMONWEALTH OF PENNSYLVANIA
Richard L. Thornburgh, Governor

DEPARTMENT OF ENVIRONMENTAL RESOURCES
Peter S. Duncan, Secretary

OFFICE OF RESOURCES MANAGEMENT
R. Timothy Weston, Associate Deputy Secretary

TOPOGRAPHIC AND GEOLOGICAL SURVEY
Arthur A. Socolow, State Geologist

CONTENTS

ON THE COVER: View from Hawk Mountain, a registered National Natural Landmark, along Blue Mountain in Schuylkill County. Formed by resistant Tuscarora Quartzite, this high vantage point is internationally known for its position along a major north-south flyway. Birdwatchers regularly frequent this prominent lookout. In the distance, Appalachian ridges of uniform height (a peneplane?) are seen erosionally sculptured to form water gaps. Photo Courtesy of Grant Heilman.

PENNSYLVANIA GEOLOGY is published bimonthly by the Topographic and Geologic Survey, Pennsylvania Dept. of Environmental Resources, Harrisburg, Pennsylvania, 17120.

Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

February 1982

FROM THE DESK
OF THE
STATE GEOLOGIST . . .

A POLICEMAN'S LOT IS NOT A HAPPY ONE
(with apologies to Gilbert and Sullivan)

In the calendar year 1981, the Oil and Gas Regulatory Division of the Pennsylvania Geologic Survey received and processed nearly 9,000 applications for oil and gas well drilling permits and an additional 4,500 applications for classifying gas wells as required under the Natural Gas Policy Act. These cold, sizable numbers not only indicate the remarkable extent of new drilling activity in Pa., but also provide a hint of how our Survey functions have been affected since the responsibilities of the Oil and Gas Regulatory Division were transferred to our Bureau in mid-1979. Since that time we have had to digest and implement an array of state and federal laws and regulations, direct our oil and gas inspectors to innumerable sites of crises and complaints, reorganize nearly 100,000 well records on file, respond to an amazing influx of mail and telephone inquiries, and meet with countless members of the oil and gas industry, as well as concerned environmental and public groups. All this while maintaining our other five long-established divisions.

We can say with confidence that we have made real progress in improving the effectiveness of the oil and gas regulatory program including closer coordination with the other involved DER bureaus and with the industry operators. We still get a lot of calls, a lot of questions, some reports of unsolved problems, and even a few complaints. But those complaints are not one-sided, indicating that we're reasonably even-handed in our procedures.

Before the days when we got involved with regulations and investigations, our services and our geologic maps and reports brought forth only praise and acclaim; we were the "good guys in the white hats". Now that we're in the permitting, regulation, and enforcement business, we face a challenge to keep our "hats from turning black." Approaching our responsibilities in a constructive vein, aiming to solve problems fairly, we believe we can meet the challenge.

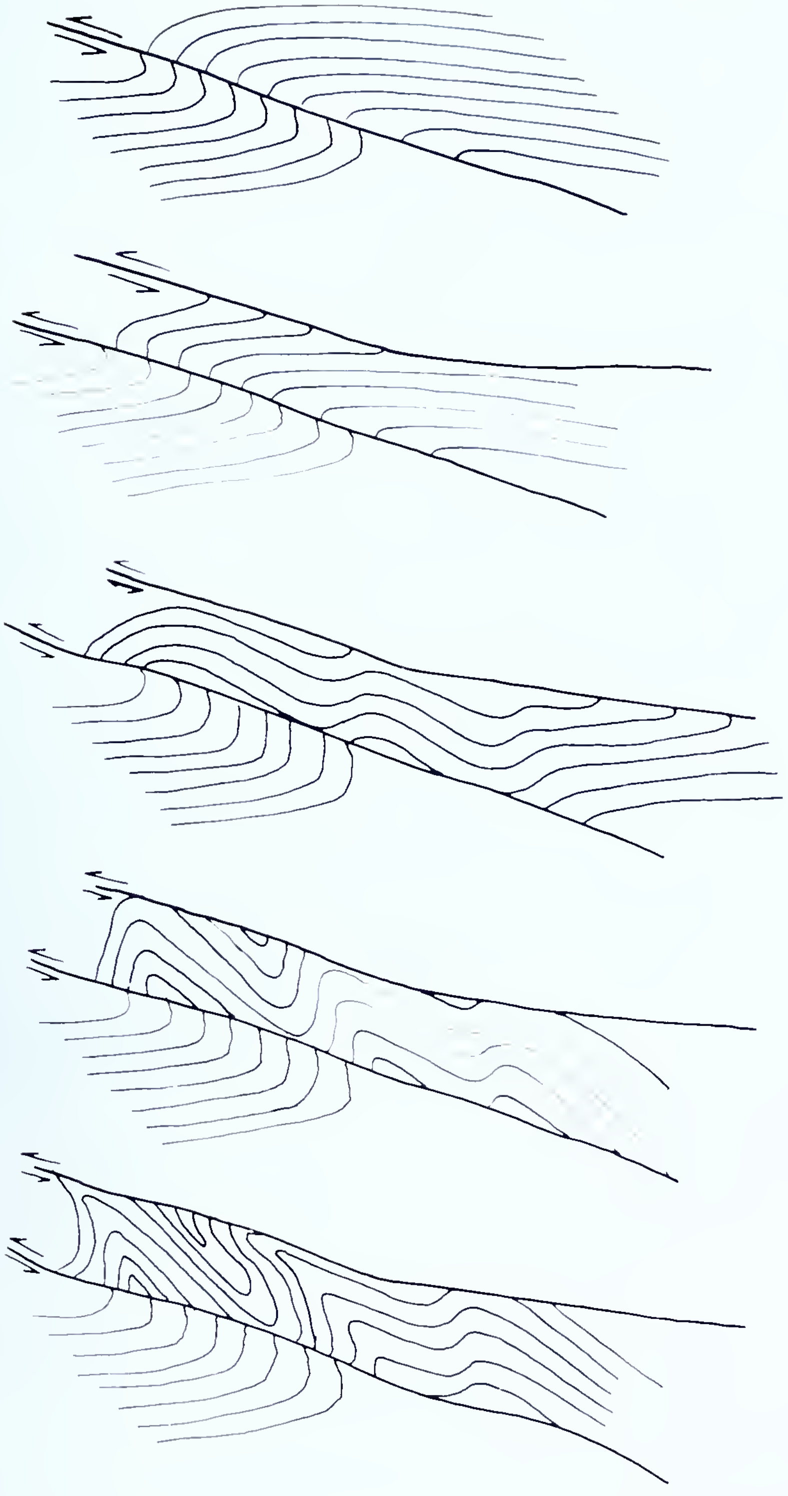
Arthur A. Socolow

THE BRIDGE STREET, TOWANDA FAULT ZONE

by Howard Pohn, U.S. Geological Survey
(Excerpted from The 1981 Field Conference of PA Geologists Guide Book)

The Bridge Street thrust-fault zone at Towanda may be one of the best exposed fault zones known on the Allegheny plateau of Pennsylvania. The faults have a minimum lateral shortening of 90 feet. The fault zone is composed of three faults; a small splay evolves from the lowermost fault. Paired or multiple faults are very common on the Allegheny plateau as well as in the valley and Ridge province and may account for 70 to 80 percent of all thrust faults in the Appalachian foldbelt in Pennsylvania. This paired or multiple fault has a moderately to severely disturbed zone between the fault planes, including characteristic "Z" folding caused by drag. Presumably, the amount of disturbance is indictive of the amount of relative displacement between the two faults.

1. Photograph of faulted Lock Haven Formation rocks in a road cut on Bridge Street, Towanda, Pennsylvania, 1/10 mile west of underpass of U.S. Route 220.



2. Schematic diagram of the evolution of disturbed zones of the Bridge Street Fault.

FOSSIL COLLECTING LOCALITY IN THE KEYSER FORMATION AT MAPLETON, HUNTINGDON COUNTY, PENNSYLVANIA

by Charles E. Miller, Jr.
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Bellaire, TX 77401

Field investigations in the Keyser Formation (Upper Silurian-Lower Devonian) of central Pennsylvania have yielded numerous localities where fossils are both prolific and varied. Some of these localities have been known to earlier workers, but none of them have previously been described for the general public in *Pennsylvania Geology* or *Fossil Collecting in Pennsylvania* (General Geology Report 40 of the Pennsylvania Geological Survey).

One such locality that is suitable for both amateur and professional collectors is an abandoned quarry (the I. N. Swope quarry of Reeside, 1918) located along Pa. Rte. 655 on the east side of the Juniata River opposite the town of Mapleton, Huntingdon County (Figure 1; 40°23′51″N/77°56′19″W, Mt. Union quadrangle). The quarry lies 0.15 mi north of the bridge across the river to Mapleton.

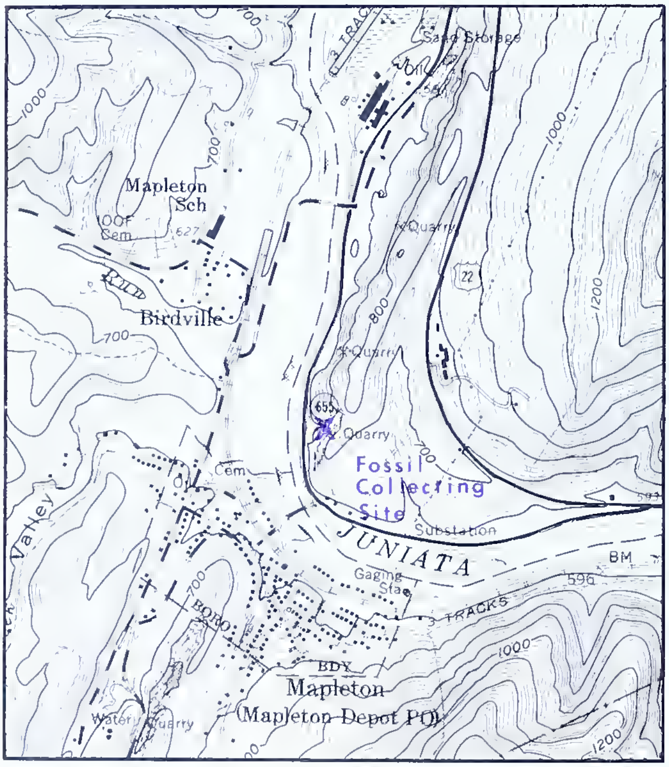

Figure 1. Location map.

Exposed in the old Swope quarry is the upper portion of the Tonoloway Formation (Upper Silurian) and nearly all of the Keyser Formation. Both formations are fossiliferous, but only Keyser fossils are noted here.

The following invertebrate fossils have been described from the Keyser Formation at this locality:

Sponges
- Unclassified stromatoporoids

Coelenterates
- *Aulopora* sp.
- *Favosites* sp.
- *Cladopora rectilineata* Simpson

Bryozoans
- *Fistuliporella minima* Ulrich and Bassler
- *Lioclema? subramosa* Ulrich and Bassler
- *Leptotrypella multitecta* Boardman

Brachiopods
- *Pholidops ovata* Hall
- *Isorthis* cf. *I. perelegans* (Hall)
- *I. concinna* (Hall)
- *I. clarki* (Maynard)
- *Rhipidomella* sp.
- *Leptaena rhomboidalis* (Wilckens)
- *Leptostrophia bipartita* (Hall)
- *Orthostrophia* sp.
- *Strophonella (Strophonella)* sp.
- *Schuchertella interstriata* (Hall)
- *S. prolifica* Schuchert
- *S. deckerensis* (Weller)
- *Gypidula prognostica* (Maynard)
- *Cupulorostrum litchfieldensis* (Schuchert)
- *Uncinulus nucleolatus* (Hall)
- *U. keyserensis* Schuchert
- *Atrypa reticularis* (Linné)
- *Meristella praenuntia* Schuchert
- *Nucleospira ventricosa* (Hall)
- *Rhynchospirina martinensis* Bowen
- *R. formosa* (Hall)
- *Whitfieldella* cf. *W. nucleolata* (Hall)
- *Howellella vanuxemi prognosticus* (Schuchert)
- *Nanothyris mutabilis* (Hall)
- *Rensselaeria keyserenis* Swartz

Bivalves
- Unclassified species

Cephalopod
- Unclassified orthocerid

Gastropod
- *Platyceras (Platystoma)* sp.

Ostracode
- *Leperditia* sp.

Annelid
- *Spirorbis laxus* Hall

Echinoderms
- Crinoid columnals
- *Sphaerocystites mutifasciatus* Hall

Cricoconarid
- *Tentaculites gyracanthus* (Eaton)

The species identified above are illustrated in Maryland Geological Survey (1913), Willard and others (1939), Bowen (1967), and Miller (1979). Representative genera from the Keyser Formation are pictured in Hoskins (1969).

Fossils are found in all rock types comprising the Keyser in the Swope quarry, particularly in nodular limestones and calcareous shales in the lower part of the formation (Figure 2). Most of the fossils can be removed from the rock matrix with little effort; however, some, such as stromatoporoids and many crinoids and corals, occur in massive limestones from which extraction of fossils is very difficult. In addition, loose, well preserved brachiopods, crinoid

Figure 2.

North wall of the Swope quarry, Mapleton, Pa. Dashed line marks approximate contact between the Keyser (DSk) and Tonoloway (Sto) Formations. Fossils can most easily be collected from nodular limestone beds (and rubble) on left side of exposed section (between arrows).

columnals, and solitary and colonial corals can readily be found scattered through the rubble on the floor and sides of the quarry. Most of the loose brachiopods are preserved with both valves intact. One of the bryozoan fossils collected here, *Fistuliporella minima*, has been regarded tentatively as an index or guide fossil to the Keyser interval and equivalents in this region.

The limestones of the Keyser Formation were deposited in the warm, shallow waters of an epicontinental sea which invaded central Pennsylvania about 405 million years ago. The Keyser sea apparently formed a broad embayment which opened to the southwest and became progressively more shallow to the northeast.

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Surplus Topographic Maps

The Survey has accumulated a quantity of out-of-print 7½′ quadrangle topographic maps. We are offering them, in limited numbers, to earth science teachers. The maps cover areas in Western Pennsylvania.

If you are interested in receiving a limited number of these maps contact Dr. Arthur A. Socolow, State Geologist, Dept. of Environmental Resources, Bureau of Topographic and Geologic Survey, P.O. Box 2357, Harrisburg, PA 17120. Maps will be supplied as long as they last on a first-come first-serve basis.

MINERAL & GEM SHOW

On April 3 and 4, 1982, the York Rock & Mineral Club will hold its 13th Annual Mineral & Gem Show at the Alert Fire Company Hall, Emigsville, PA.

For further information contact Frederick E. Clark, R.D. #1, Box 47, Hanover, PA 17331.

LEAFLET EXPLAINS RICHTER, MERCALLI EARTHQUAKE SCALES

A leaflet explaining how the severity of an earthquake is expressed by two commonly used but highly different methods—the Richter Scale and the Modified Mercalli Intensity Scale—is available for public distribution from the U.S. Geological Survey.

The leaflet, written in nontechnical terms, was prepared to help clarify confusing concepts related to the measurement of earthquakes. Earthquakes can be measured in terms of either the energy released (magnitude) or the effects (intensity). The former is based on instrument recordings; the latter on personal observations. The two methods, expressed by highly differing scales, are often confused by the public.

Single copies of the 15-page illustrated leaflet, titled "The Severity of an Earthquake," may be obtained free upon request from the U.S. Geological Survey's Branch of Distribution, 1200 South Eads Street, Arlington, Virginia 22202.

A few "briefs" from the leaflet:

The *intensity* of an earthquake is based on observed effects of ground shaking on people, buildings, and natural features. It varies from place to place within the disturbed region depending on the location of the observer with respect to the earthquake epicenter. Intensity is expressed by the Modified Mercalli Intensity Scale.

The *magnitude* of an earthquake—expressed by the Richter Scale—is related to the amount of seismic energy released at the focal depth of an earthquake. It is based on the amplitude of earthquake waves recorded on instruments which have a common calibration.

Earthquakes are the result of forces deep within the Earth's interior. The energy from these forces is stored in a variety of ways within the rocks. When this energy is released suddenly, for example, by shearing movements along faults in the Earth's crust, an earthquake results. The area of the fault where the sudden rupture takes place is called the focus or hypocenter of the earthquake. The point on the Earth's surface directly above the focus is called the epicenter of the earthquake.

Seismic waves are vibrations from earthquakes that travel through the Earth, and they are recorded on instruments called seismographs. The instruments record a zig-zag trace that shows the varying amplitude of ground oscillations beneath the instrument. Sensitive seismographs, which greatly magnify these ground motions, can detect strong earthquakes from sources anywhere in the world. The time, location, and magnitude of an earthquake can be determined from the data recorded by seismograph stations.

The Richter Scale was developed in 1935 by Dr. Charles F. Richter of the California Institute of Technology. On this mathematical scale, which is open-ended, magnitude is expressed in whole numbers and decimals. For example, a magnitude 5.3 might be computed for a moderate earthquake, and a strong earthquake might be rated as magnitude 6.3. Because of the logarithmic basis of the scale, each whole number increase in magnitude represents a tenfold increase in measured amplitude; thus, as an estimate of energy, each whole number step in the scale corresponds to the release of about 31 times more energy than the amount associated with the preceding whole number value.

Earthquakes with magnitude of about 2.0 or less are usually called microearthquakes; they are not commonly felt by people and are generally recorded only on local seismographs. Events with magnitudes of about 4.5 or greater—there are several thousand such shocks annually—are strong enough to be recorded by sensitive seismographs all over the world. Great earthquakes, such as the 1906 San Francisco earthquake and the 1964 Good Friday earthquake in Alaska, have magnitudes of 8.0 or higher. On the average, one earthquake of such size occurs somewhere in the world each year. Although the Richter Scale has no upper limit, the largest known shocks have had magnitudes in the 8.8 to 8.9 range.

The Richter Scale is not used to express damage. An earthquake in a densely populated area which results in many deaths and considerable damage may have the same magnitude as a shock in a remote area that does nothing more than frighten wildlife.

The effect of an earthquake on the Earth's surface is called the intensity. The intensity scale consists of a series of certain key responses such as people awakening, movement of furniture, damage to chimneys, and finally—total destruction. Although numerous intensity scales have been developed over the last several hundred years to evaluate the effects of earthquakes, the one currently used in the United States is the Modified Mercalli Intensity Scale, developed in 1931 by the American seismologists Harry Wood and Frank Neumann.

The Modified Mercalli Intensity Scale is composed of 12 increasing levels of intensity that range from imperceptible shaking to catastrophic destruction designated by Roman numerals (I to XII). It does not have a mathematical basis; instead, it is an arbitrary ranking based on observed effects. The Modified Mercalli Intensity Scale provides a more meaningful measure of severity to the nonscientist than magnitude because it refers to effects actually experienced.

The following is an abbreviated description of the 12 levels of the Modified Mercalli Intensity Scale:

I. Not felt except by a very few under especially favorable conditions.

II. Felt only by a few persons at rest, especially on upper floors of buildings.

III. Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration similar to the passing of a truck. Duration estimated.

IV. Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sounds. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.

V. Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.

VI. Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.

VII. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.

VIII. Damage slight in specially designed structures. Considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.

IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundation.

X. Some well built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.

XI. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.

XII. Damage total. Lines of sight and level are distorted. Objects thrown into the air.

Fissures such as these occur commonly on steep slopes in western Pennsylvania, some of which may have been triggered by seismic events.

Out-of-Print Topographic Maps

Out-of-print maps are valuable to historians, environmentalists, genealogists and others interested in researching the development of a particular area. The National Cartographic Information Center-NCIC-has made these old maps available on microfilm and microfilm reproductions.

The files of the U.S. Geological Survey contain copies of virtually all the topographic maps published by the Survey since 1884. Except for the current edition of a map, others are contained on 35-mm microfilm. In this way, the vast inventory is limited to current maps, yet copies of older maps can be provided.

ORGANIZATION

The collection comprises over 120,000 maps, including some 15-minute quadrangle maps compiled by the U.S. Army Corps of Engineers, National Parks and Monument maps, River Survey maps, and selected Federal Highway Administration county planning maps. The collection continues to grow as other types of maps are added.

The rolls of USGS microfilm are divided chronically into subsets:

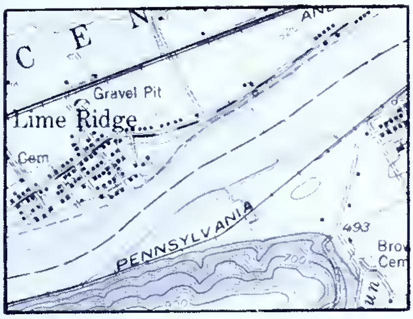
- Maps published from about 1884 through December 1972—"A" series
- Maps published from January 1973 through September 1977—"B" series
- Maps published from October 1977 through September 1979—"C" series
- Maps published from October 1979 through September 1980—"D" series

Additional subsets will be prepared annually and designated "E," "F," etc. series.

Within each subset the rolls are organized by State. The maps of each state are filed alphabetically by quadrangle name. More than one map may appear in a single frame, depending on the size of the original maps.

Each map copy retains the publication and legend information of the original. In addition, each map image contains an identifying strip that notes the State or States covered; an anronym indicating the Federal agency that produced the original map; and a roll-frame identification number.

The microfilms of original maps are made and retained on very high-quality 35-mm film with a fine-grained antihalation undercoat. The emulsion is silver halide.



← Out-of-print map of part of the Bloomsburg 15′ quadrangle

↓ Current map of same area (Mifflinville 7½′ quadrangle)

Most of the maps are filmed at a reduction factor of 20x; however, some of the large-size and small-size maps are filmed at other reduction ratios. The images of maps so treated bear a note of the reduction factor employed.

PRODUCTS AVAILABLE

Film Copies — Microfilm rolls of out-of-print maps may be ordered from the National Cartographic Information Center (NCIC). The microfilm roll will fit most standard 35-mm readers.

Two kinds of film copies are available:

- Diazo. A commonly used type of microfilm, diazo is easily handled and stored, resists scratching, but will eventually fade. It is inexpensive compared to other types of microfilm.
- Silver halide emulsion. The high-quality microfilm is used by the USGS for its own files. The film is very durable if kept in a controlled temperature and humidity environment, but the emulsion is easily scratched.

Copies of the maps stored on these microfilm rolls can be made by a 35-mm reader/printer or through the photographic enlargement and printing process. An enlargement made from microfilm is not the same quality as the original. A slight shrinkage in size occurs; this causes the scale to be slightly distorted relative to the original map. However, the bar scale remains true within the reproduction, so that the position of all features are correct in relation to each other. The sharpness of the reproduction also depends on the condition of the original map. Some older maps may have faded or suffered other reductions in quality before they were microfilmed.

Paper Reproductions — Black and white paper reproductions are also available from NCIC. These "blowback" reproductions are nearly true scale and of reasonable legibility, but they are subject to fading.

ORDERING

Paper reproductions can be ordered by identifying the state and quadrangle, and date of the map you are interested in. Each reproduction cost $3.00.

Roll microfilm can be ordered by identifying the state, series and type of microfilm desired. Diazo microfilm cost $10.00 per roll and Silver halide emulsion is $20.00 per roll.

Prepayment is required in the form of check or money order payable to U.S. Geological Survey. Your order will take between two and three weeks. Ordering address is:

National Cartographic Information Center
Eastern Section
536 National Center
Reston, Virginia 22092
Telephone: 703/860-6336

For more information write to the above address for the brochure "How to Order Maps on Microfilm" and "Out-of-print Maps", both of which include order forms. This article is condensed from these brochures.

20 Years as State Geologist

Arthur A. Socolow, Director of the Bureau of Topographic and Geologic Survey and State Geologist was honored in December with a surprise celebration of the 20th anniversary of his appointment by the Honorable Genevieve Blatt, Secretary of Pennsylvania's Department of Internal Affairs in 1961, as State Geologist of Pennsylvania.

Art started his career with the Bureau on June 17, 1957 as a Mineral Resource Geologist until his appointment as State Geologist in December 1961. Some of the significant milestones during the two decades of his directing the Bureau have been the transfer of the Bureau from Internal Affairs to the State Planning Board and then to the Department of Environmental Resources and most recently, the addition of a new Division, The Division of Oil and Gas Regulation. During this period, Art oversaw the initiation of this magazine, "Pennsylvania Geology," as well as the start of several new series of publications: the Educational Series, now totaling 9 reports; the State Park Guides of which 15 have been published; and the Environmental Geology Reports now at 7 publications. Also in a cooperative program with the U.S. Geological Survey, 7.5-minute topographic map coverage of the entire State was completed during his tenure and a new series of county topographic maps was started, largely at his insistence.

Through his editorials in "Pennsylvania Geology" as well as in numerous public meetings, Art has continued to press for the application of the geology published by the Bureau in the process of planning for the future to strike a balance between mineral and water resource utilization, wise land use, and protection of the environment.

Under Art's direction, 40 quadrangle Atlases have been published as well as 1 County Report, 35 General Geology Reports, 36 Information Circulars, 51 Maps, 37 Mineral Resource Reports, 34 Progress Reports, 1 Special Bulletin, and 36 Groundwater Reports.

The most recent major accomplishment of the Bureau during Art's tenure as State Geologist, is the complete revision of Map 1, The Geologic Map of Pennsylvania, which replaces the 1960 edition and represents a major improvement in the geologic knowledge of Pennsylvania.

EMPLOYMENT OPPORTUNITIES IN THE GEOLOGICAL SCIENCES

The Geological Society of America (GSA) has issued a 15-page booklet entitled *Future Employment Opportunities in the Geological Sciences.* The new booklet contains the assessment of geologic employment as presented by six distinguished professional geologists representing the fields of industry, government, and academia.

This information booklet is available at no charge by writing to: The Geological Society of America, P.O. Box 9140, Boulder, Colorado 80301.

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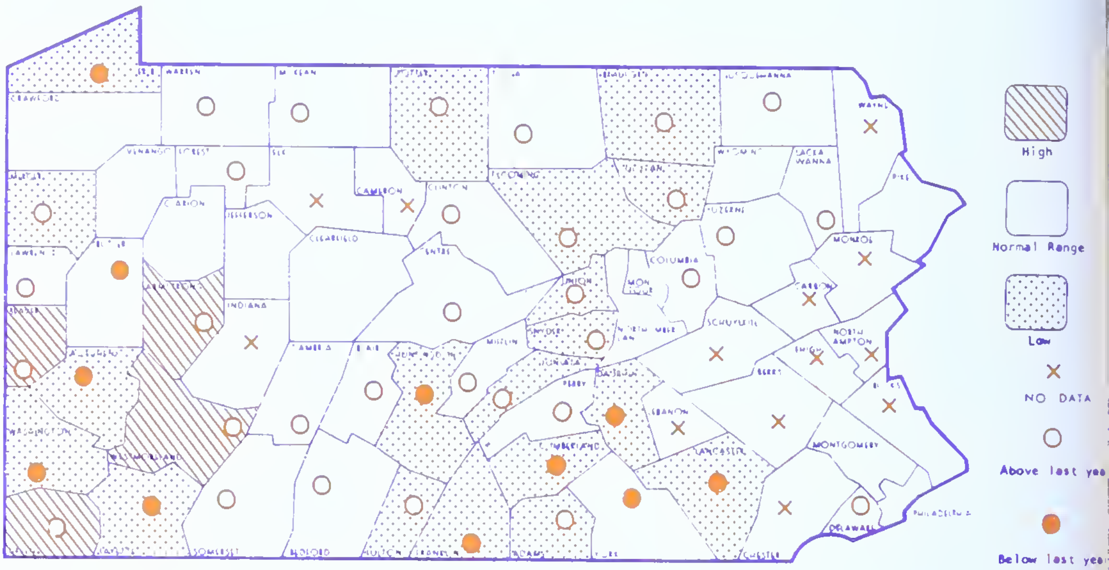
GROUND WATER LEVELS

FOR

December 1981



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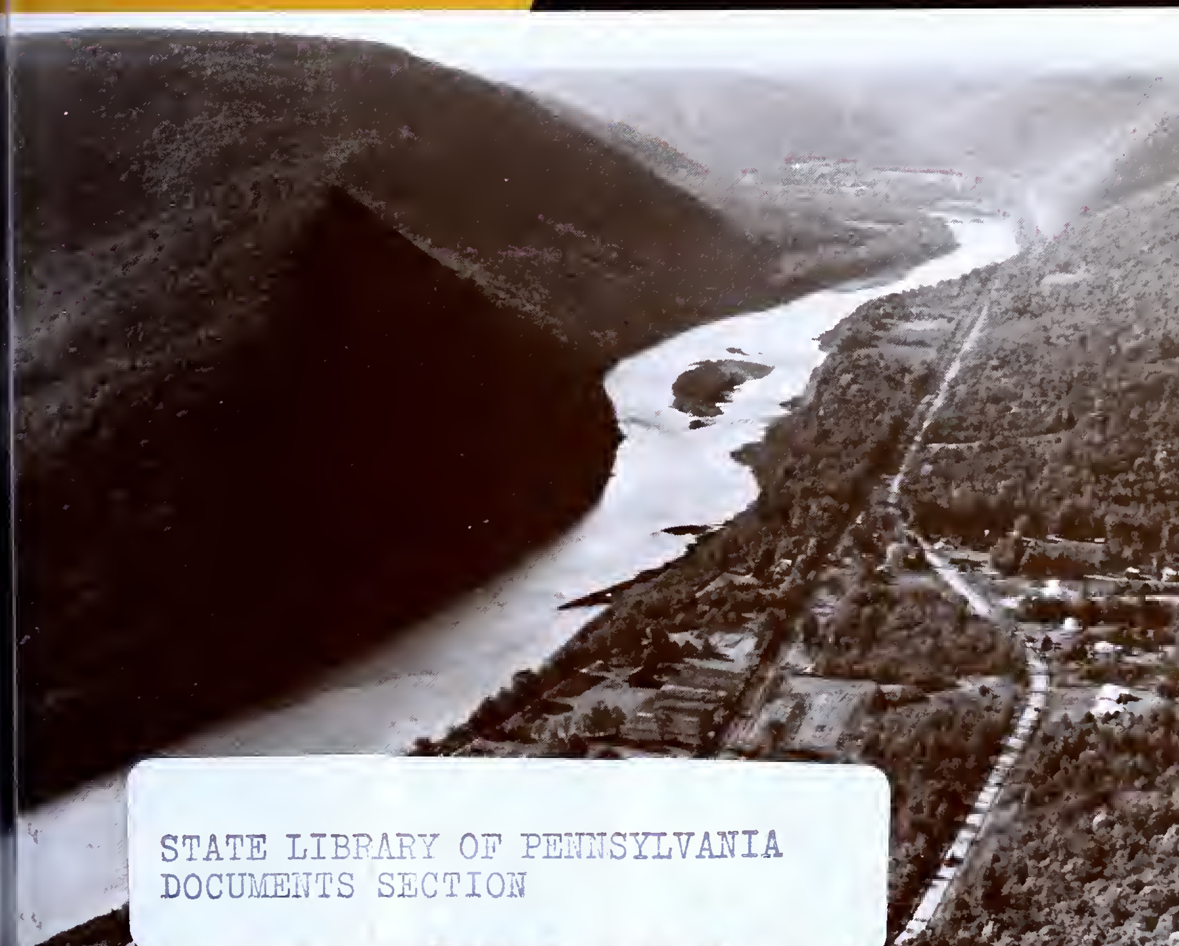

THE PENNSYLVANIA GEOLOGICAL SURVEY VOL. 13/2

COMMONWEALTH OF PENNSYLVANIA
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DEPARTMENT OF ENVIRONMENTAL RESOURCES
Peter S. Duncan, Secretary

OFFICE OF RESOURCES MANAGEMENT
R. Timothy Weston, Associate Deputy Secretary

TOPOGRAPHIC AND GEOLOGICAL SURVEY
Arthur A. Socolow, State Geologist

CONTENTS

ON THE COVER: Hyner View in Hyner State Park, along Route 120, 6.5 miles east of Renova, Clinton County. West Branch of Susquehanna River is downcutting into Catskill Formation, ridges are capped by Burgoon Formation.

PENNSYLVANIA GEOLOGY is published bimonthly by the Topographic and Geologic Survey, Pennsylvania Dept. of Environmental Resources, Harrisburg, Pennsylvania, 17120.

Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

April 1982

FROM THE DESK

OF THE

STATE GEOLOGIST . . .

HOW I GOT INTO THE MOVIES (ALMOST)

On one normally hectic day last fall our secretary buzzed me to say that I had a call from Hollywood. Knowing of their continuing need for new talent, yet not wishing to appear overly eager, I nonchalantly answered the phone. It was not me they were after, it was Pennsylvania anthracite coal.

It seems that in one of the scenes they were filming for the movie entitled "One From the Heart" there is a miniature movie set for which they wanted the ground to appear as truly black sand. Since nothing else had photographed as desired, the set designer came up with the idea of using pulverized coal, and only the shiny, clean anthracite variety would do. And they needed it within 96 hours — whatever the cost.

While I knew where I could get the 200 pounds of anthracite they needed, there were still some hurdles to overcome. There was no place around here that could pulverize the coal to specifications that quickly; no problem, the studio people said they would take care of the pulverizing — just get the coal out there — fast, and not to worry about the expense. Called the air express people; sorry, coal is combustible and therefore not allowed on planes, even when I suggested bagging it like a passenger. I began to fret; but two heads are better than one, and from my secretary came "Why not ship it by express bus?" A couple of calls verified this approach and we were in business.

That evening I made my first coal purchase in 35 years and wrestled the 200 pounds of gleaming anthracite into four double bags — cloth and paper, so as not to leak away in its cross-country travels.

Next morning, 24 hours after Hollywood called, I pulled up to the bus station and dragged those sacks of Pennsylvania black gold onto the baggage scales. "What have you got there?" the clerk asked. "Just some Pennsylvania coal heading for Hollywood," I replied. Raised eyebrows and laughter followed.

And so it was. 96 hours later came a phone call from California; the coal had arrived in the nick of time, had been pulverized, and was the perfect material for the movie set. Movie producer Francis Ford Coppola was delighted and salutes our gleaming anthracite.

So if any of you should happen to see "One From The Heart," you won't see me in it. But there's a bit of Pennsylvania there — you'll have to look close, because it blends well into the setting.

No, I didn't make it in pictures; Hollywood beckoned, opportunity knocked, and I answered with Pennsylvania's anthracite. Oh well, we also serve.

Arthur A. Socolow

"Oriskany" Sandstone Oil Potential, Northwestern Pennsylvania

by John A. Harper
Pennsylvania Geological Survey

The Lower Devonian "Oriskany" Sandstone* has long been known as one of the more prolific producing horizons for natural gas in Pennsylvania. A handful of large "Oriskany" fields, such as Leidy field in Clinton and Potter Counties and the Punxsutawney-Driftwood field in Clearfield, Elk, and Cameron Counties, accounted for 50 percent or more of the total natural gas produced in the Commonwealth during the 1950's. Today the "Oriskany" has taken a back seat to the Lower Silurian Medina Group in terms of total completed wells drilled each year, but recent "Oriskany" wells in Somerset County are reportedly some of the best producing wells in Pennsylvania.

Despite the good track record of the "Oriskany" as a gas producer, it has never produced oil in Pennsylvania, nor is it considered an outstanding producer in adjacent states. The sand first produced oil at the rate of about 1½ barrels per day from a well in the Austinburg field of Ashtabula County, Ohio, in 1899. However, commercial production of oil from the "Oriskany" did not actually take place until the mid-1920's when oil was discovered in the updip areas of Cambridge field in Guernsey County, Ohio (Hall, 1952). Some oil has also been produced in "Oriskany" wells in western West Virginia, but in Pennsylvania only shows have been reported in this unit. Fettke (1935) first indicated the potential for "Oriskany" oil production in the Bradford area of McKean County. Later, he illustrated an area in western Crawford County having good shows of oil in the sand (Fettke, 1938, 1940). I would like to concentrate on this particular area, the Conneaut field, as a potential oil producing region in the "Oriskany" Sandstone.

---

*The term "Oriskany" is used here in quotation marks to indicate the questionable usage of the name for a unit which has not specifically been correlated with the type section of the Oriskany Sandstone in New York (see Heyman, 1977; also Abel and Heyman, 1981, for discussion).

The Conneaut field occupies about 250,000 acres in western Erie and Crawford Counties in northwestern Pennsylvania. It comprises a large number of isolated or partially merged pools in the Lower Silurian Medina Group, with subsidiary production from small pools in the Upper Devonian Venango Group, Lower Devonian "Oriskany" Sandstone, Middle Silurian Lockport Dolomite, and Upper Cambrian Gatesburg Formation. A small number of wells in the area just north of Beaver Center, Beaver Township, Crawford County (Figure 1), had reported shows of oil from the "Oriskany" ranging from "show of oil" to 12 barrels per day. These wells, drilled around 1910 for the most part, encountered the "Oriskany" at about 2,300 feet below the surface. No commercial production of oil is known to have occurred.

The "Oriskany" Sandstone in this area, and throughout northwestern Pennsylvania, has a rather patchy distribution. Where it occurs it is typically less than 20 feet thick. This patchiness may serve to create traps where the low, almost featureless structures in the subsurface coincide with development (non-erosion?) of the sand. Wells drilled in these sand traps typically have moderate to large flows of natural gas. The Meade pool in Erie field, Erie County, was discovered in 1946; the discovery well flowed 420 thousand cubic feet of gas per day (Mcfpd). About 60 subsequent wells were drilled in the area in a short time, but the flows could not be sustained. Meade pool, now called Summit Storage pool, was converted to gas storage in 1959, just 13 years after discovery of gas. Typically, storage areas are located in rocks exhibiting excellent reservoir characteristics such as high porosity and permeability, and low water saturation. The McKean pool, also in Erie field, was discovered in 1973 when a well was completed with a natural open flow of 15,000 Mcfpd. The single well pool was shut-in in 1979 after producing a cumulative 135,561 Mcfpd. In Conneaut field two "Oriskany" pools were discovered in the mid-1960's. The Springfield pool discovery well was completed with a natural open flow of 5,600 Mcfpd, and Kidders Corner pool (actually a single commingled "Oriskany" and Medina well) had a reported natural open flow of 7,500 Mcfpd from the "Oriskany." All of these examples are typical of "Oriskany" production, where it occurs, in Erie and Crawford Counties.

The sandstone, as observed in cuttings from the Appalachian Development #1 Cozad well (well #5 in Figures 1 & 2), contains abundant subangular to well-rounded, medium- to coarse-grained, yellowish to clear quartz grains with some minor shaliness (the

shale could be cavings from up-hole). The grains appear to be cemented with calcite in the upper portions of the formation. The samples appear to indicate that there is very little intergranular porosity, but the neutron porosity logs in the area around the oil shows indicate a formation porosity of about 10 percent. A few of the samples observed had clusters of tightly cemented quartz grains with a dark organic-looking substance (bitumen?) in the interstices. It should be noted that the samples described above came from a zone of good quartz sand immediately beneath the horizon referred to by Heyman (1977) as the Bois Blanc Formation. The Bois Blanc carbonates, because of their characteristic clastic content (normally siltstones, shales and fine-grained, glauconitic sandstones), are often identified by drillers as the "Oriskany" in drilling records, especially where the lower sand unit is absent.

Figure 1 shows structure contours on top of the overlying Onondaga Group. The Onondaga was chosen for structural control in this study because of the patchy distribution of the "Oriskany" Sandstone and the unreliability of drillers' records in picking the sand with any degree of accuracy (see the discussion above). Where electric logs are unavailable the top of the Onondaga is generally more

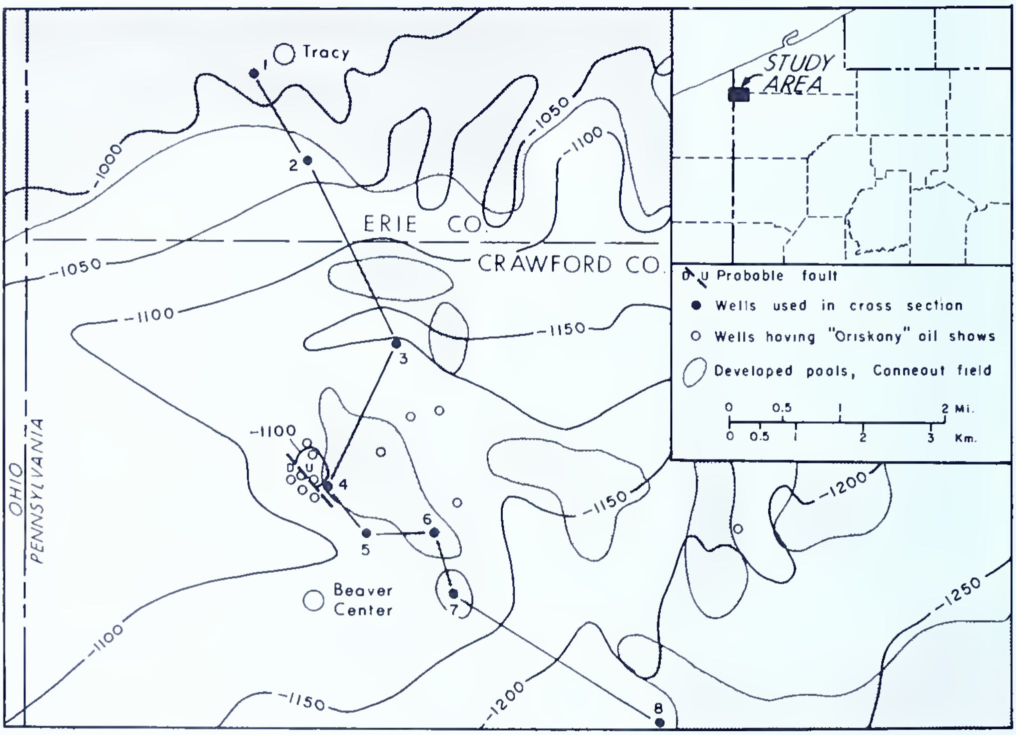

Fig. 1 Location of study area showing "Oriskany" oil shows, locations of wells used to construct cross section (Figure 2), and structure contours on top of the Onondaga Group. Contour interval is 50 feet.

reliable because it is readily identifiable during drilling. Regional structure on the Onondaga indicates a gentle dip to the southeast (about 50 feet per mile), keeping in line with regional structure in the Allegheny Plateau of Pennsylvania. However, in the area around the oil shows in the "Oriskany" the contours bend back on themselves, indicating a gentle anticline over the area of interest. A cross section of the area (Figure 2) corroborates the anticline interpretation and indicates the structure is related to changes in the thickness of the Upper Silurian Salina Group, about 600 feet below. Other cross sections prepared during this study indicate a probable direct relationship between changes in Salina thickness, particularly in the Unit C shale and Unit D salt (see Fergusson and Prather, 1968), and distribution of "Oriskany" sand in the area. On a smaller scale, subsea elevations on top of the Onondaga Group indicate questionable faulting of the section in conjunction with isolated structural highs and lows, also associated with thickening and thinning of the Salina Group. The structural picture at this scale is much too confused by problems of incorrectly reported elevations and formation tops, however, so that no attempt has been made to present a more comprehensive structure contour map than that shown in Figure 1. Faulting, if it occurs in the "Oriskany" and Onondaga sections, is probably not related to faulting described by Wagner (1966) in the Cambrian and Lower Ordovician section in the same area. The plasticity of the Salina salt beds and the Upper Ordovician shales would have absorbed the small 15 or 20 foot displacement observed by Wagner.

The "Oriskany" Sandstone, therefore, exists in the area north of Beaver Center as a relatively isolated patch of sand, thinning to the north and south, situated on a structural high. The sand is good quality reservoir material with formation porosity of about 10 percent. Considering the nearly ideal reservoir and trap conditions of the "Oriskany" in this area, it might seem odd that oil and/or natural gas development from this sand has not been undertaken in more recent times. Several factors could account for lack of development. One of these, and perhaps the most important, is the fact that the Lower Silurian Medina Group sandstones have historically been commercially productive in Erie and Crawford Counties, especially in Conneaut field. The recent designation of the Medina Group as a tight formation by the Federal Energy Regulatory Commission now enables operators to obtain significantly higher prices for gas produced from this reservoir. This in turn makes the Medina an even more attractive target than ever before. Another factor which could account for the lack of "Oriskany" development is connate water in

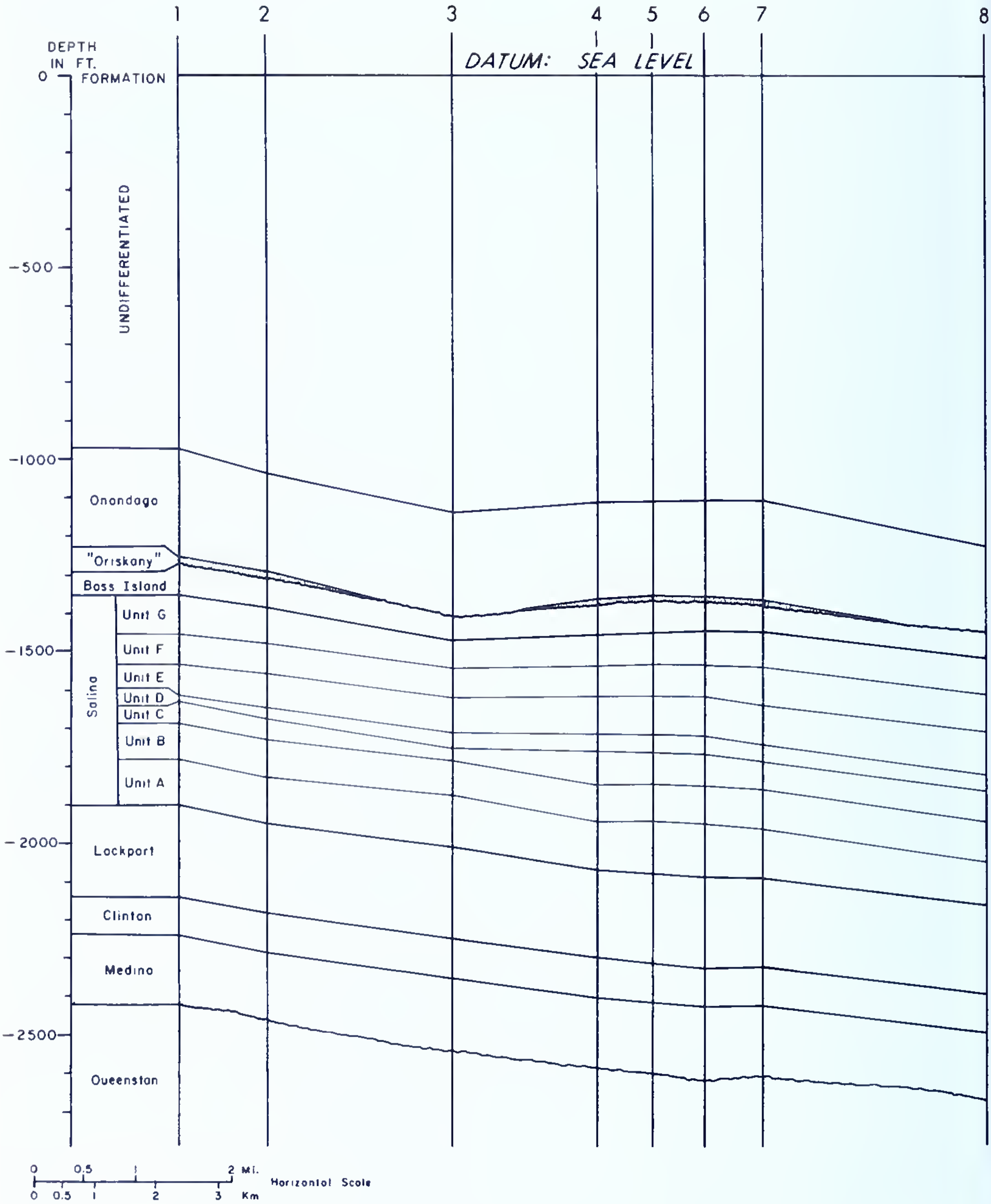

Fig. 2 Structure cross section through study area showing positions of subsurface geologic formations from Onondaga Group to Queenston Formation. Notice patchy development of "Oriskany" Sandstone. Formation tops and "Oriskany" lithology were derived from nuclear logs and samples of wells on file at Oil and Gas Geology Division, Pennsylvania Geological Survey.

the formation. "Oriskany" water content is a known factor to drillers in the northwestern counties, something taken into account while the well is still in the planning stages. Many potentially good "Oriskany" wells have been abandoned or drilled deeper because of flooding problems. One of the "Oriskany" oil wells north of Beaver Center had a show of 12 barrels per day of oil, but 100 barrels per day of water. This particular well, the Patterson #1 George well, was drilled in 1934, a relatively late date for the wells shown in Figure 1, yet no production occurred. Oil recovery technology has improved considerably since that time, however, and it is conceivable that, with present oil prices, economically feasible wells can be drilled that produce large volumes of water along with the oil. The biggest obstacle to such recovery is proper disposal of the water.

The "Oriskany" Sandstone in northwestern Pennsylvania should not be ignored as either an oil or a gas producing formation. Actual distribution of "Oriskany" sand and flooding by connate waters are the only real problems. As such, even though the "Oriskany" could be considered a likely target for drilling in this area, it probably would fare better as a secondary target for wells drilled to deeper horizons. Operators who quickly drill to the Medina Group and evaluate only that portion of the section would do well to take a closer look at the formations up-hole, especially at the "Oriskany" Sandstone.

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Our Publications Have A Market

To those who may wonder if there are users of our geological bulletins and maps, we are pleased to report that in calendar year 1981, the State Book Store filled orders for 14,282 of our technical cost publications. This, of course, does not include the elementary geology pamphlets of our educational series which we supply on request each year to over 100,000 Pennsylvania citizens of all ages and all walks of life.

This response to our publications indicates that we are pretty much "on the mark" in identifying the geologic interests and needs of Pennsylvania's citizenry.

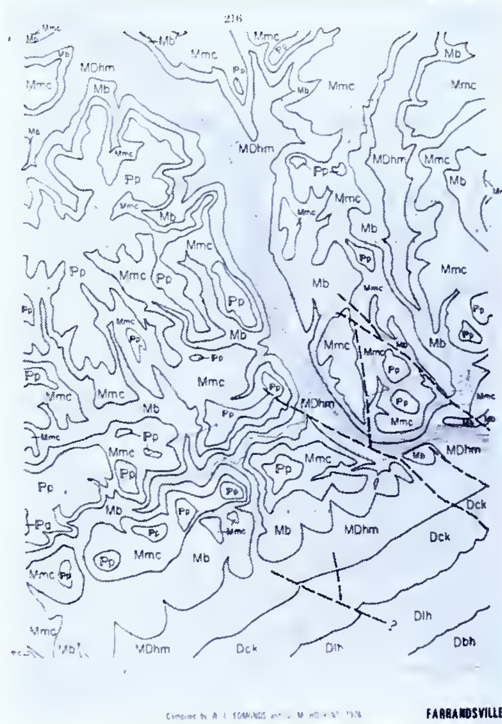
The top ten of our geologic publications sales last year were:

Map 1	Geologic Map of Pennsylvania	593 Sold
EG 7	Outstanding Scenic Geological Features of Pennsylvania	485
Map 3	Oil and Gas Fields of Pennsylvania	405
G 40	Fossil Collecting in Pennsylvania	378
G 33	Mineral Collecting in Pennsylvania	303
PR 193	Oil and Gas Developments in Pennsylvania in 1979	277
Map 19	Oil and Gas Well Base Map of the Brookville, DuBois, Hallton, and Marienville 15′ Quadrangles	235
M 62	Oil and Gas Geology of the Kinzua Quadrangle, Warren and McKean Counties	146
IC 88	Coal Resources of Pennsylvania	136
PR 192	Oil and Gas Developments in Pennsylvania in 1978	133

WHITING REPORT ON OPEN FILE

A reconnaissance study of potential carbonate "whiting" resources has been completed and placed on open-file for examination at the Mineral Resources Division of the Pennsylvania Geological Survey. The location is Room 914, Executive House, 101 S. Second Street, Harrisburg, Pa. In addition to the report, reference rock samples of various sites investigated may be examined. Nineteen samples from fourteen sources ranging in age from Precambrian to Triassic, were analyzed for brightness, whiteness, and chemical characteristics. Potential economic resources have been identified in three formations of southeastern Pennsylvania.

ATLAS OF PRELIMINARY GEOLOGIC QUADRANGLE MAPS OF PENNSYLVANIA



The compilation sheets used in preparation of the new State Geologic Map of Pennsylvania are now available for purchase as Map 61, Atlas of Preliminary Geologic Quadrangle Maps of Pennsylvania. As they were completed, these compilation maps have been available on open file at the Harrisburg offices of the Bureau of Topographic and Geologic Survey. Increasing demand for these maps has prompted publication of the maps in black and white at a scale of 1:62,500. This atlas of 624 preliminary geologic maps is published as a package of 8½ by 11 inch, pre-punched sheets which will fit standard 3-ring binders. The atlas was assembled and edited by T. M. Berg and C. M. Dodge. The geology is drawn on a topographic base, generally the latest 7½-minute quadrangle map (see example of Farrandsville quadrangle). As a time-saving measure, some of the geology was drawn on the older 15-minute base maps in parts of northwestern Pennsylvania.

An index map is included with Map 61 which shows all of the quadrangles in the Commonwealth. The maps included in this atlas are identified by an overprint on the index. For those quadrangle maps not included, the user can refer to an included list of all pub-

lished Pennsylvania Geological Survey or U.S. Geological Survey maps and reports which are available for purchase; they are also available for inspection in many libraries. The geologic maps in Map 61 show mapping that is for the most part, not published anywhere else. Users should keep in mind that these maps are preliminary and do not compare with the detailed and highly accurate, full-color geologic maps that accompany the published Pennsylvania Survey quadrangle Atlas Series, County Reports, and Water Resource Reports, or the U.S. Geological Survey Geologic Quadrangle or Miscellaneous Geologic Investigations Series. This atlas of preliminary maps should be of considerable use to consultants, planners, students of geology, and those concerned with developing rock and mineral resources and fossil fuels. Map 61 may be ordered from the State Book Store, P.O. Box 1365, Harrisburg, PA 17125. The price is $9.60 (Pennsylvania residents should add 6% sales tax).

EARTH SCIENCE TEACHERS' CORNER

new films

The following films were shown recently at the annual meeting of the Geological Society of America:

WHEN THE EARTH MOVES: 22 min., Discusses methods available to people and their governments to lessen or avoid the damages associated with the geologic hazards of volcanic eruptions, earthquakes, landslides, swelling soils and flooding. Dist: Modern Talking Picture Service, Inc., 500 Park Street, N., St. Petersburg, FL 33709 (813) 541-6661.

EARTHQUAKES AND TECHNOLOGY: Film looks at California's second most expensive earthquake — the 1971 San Fernando earthquake — and some of the difficulties involved in conducting research to reduce such hazards. Dist: University Media, P.O. Box 881, Solana Beach, CA 92705 (714) 755-1260.

GLACIAL GEOLOGY — INTERIOR PLAINS REGION: 29 min., The evolution, effects, and processes of Pleistocene glaciation, character and influence of bedrock formations. . .Precambrian rocks at the western edge of the Shield. Dist: Cherry Film Productions Ltd., 25 Bell Street, Regina, Saskatchewan, Canada S4S 4 B7 (306)586-5177.

GEMS OF THE AMERICAS: 30 min, An educational film with the intent of introducing the audience to the origin, natural history and human significance of gemstones. Dist: Gemological Institute of America, 1660 Stewart St., Santa Monica, CA 90404 (213) 829-2991.

THE ROLE OF COAL: 17 min, Explains and illustrates the past and present role of coal as an energy source, as a raw material in chemical and industrial products, and its physical characteristics as a natural resource. Dist: Indiana University Audio Visual Center, Bloomington, IN 47405 (812) 337-8087.

VOLCANO: THE BIRTH OF A MOUNTAIN: 24 min, The formation of Mauna Ulu, the first new volcanic mountain in the United States in historic times, is documented in "Volcano: The Birth of a Mountain." Encyclopedia Britannica Educational Corporation, 425 North Michigan Avenue, Chicago, IL 60611 (132) 321-7105.

CONTINENTAL DRIFT: 30 min, An entertaining and provocative film with computer animation of the drifting continents through 500 million years. Basic concepts of plate tectonics are illustrated and explained by three humorous explorers. Dist: Green Mountain Post Films, Inc., P.O. Box 229, Turner Falls, MA 01376 (413)863-4754/8248.

GROUNDWATER — A PART OF THE HYDROLOGIC CYCLE: 29 min, The film illustrates the occurrence of springs, and the role of groundwater in: soil leaching and saline soil genesis, river bank erosion and landslides, genesis of caves, and the origins of stream flow. Dist: Cherry Film Productions Ltd., 25 Bell Street, Regina, Saskatchewan, Canada S4S 4 B7 (306) 586-5177.

STORM-INDUCED LANDSLIDING, JUNE 1981, IN NORTHWESTERN PENNSYLVANIA

by John S. Pomeroy, U.S. Geological Survey, Reston, Va. 22092 and
Jeffrey W. Popp, Tulane University, New Orleans, La. 70115

On June 9, 1981, torrential rains drenched a large area of northwestern Pennsylvania. A minimum of 4 inches of rain fell on an area 70 miles long by 10 miles wide, trending east-southeast from Crawford County to Jefferson County (fig. 1). Within this same area, higher amounts ranged from about 4.5 inches recorded at Franklin and Cooksburg to 6.4 inches at Cooperstown (National Weather Service, written commun., 1981). Flood damage was particularly extensive along Sage Run southeast of the main part of Oil City.

A brief reconnaissance was made of slopes in the Oil City-Franklin area two weeks after the storm and saw many fresh scars caused by soil slippage. Most of the scars are enlargements of recent slides that were observed during 1978 in a regional slope stability inventory. Most of the landslides occur along man-modified slopes underlain by the Cuyahoga Group of Mississippian age as mapped by Ward and others (1979).

Although the June 1981 storm was considerably wider in extent and was slightly more intense than the Brady's Bend storm of August 15, 1980 (Pomeroy, 1980a), its effect on slopes was less pronounced. A lower landslide density resulted from the storm because of factors related to pre-storm soil-moisture conditions, topography, and geologic and soil materials.

A rainfall of 4 inches for the four-week period prior to the storm contrasts sharply with amounts of 7.5 to 9.5 inches in the Brady's Bend area for the same length of time prior to the August 1980 storm. Thus, soils in the 1981 storm area were considerably less saturated than they were in the previous year's storm at Brady's Bend.

Overall, the slopes in the area of the June 9th storm are more moderate than those in the much smaller area affected by the August 1980 storm. Most of the mass movement of the June 1981 storm was restricted to the steep hillsides along the Allegheny River between Franklin and Oil City. The most intense rainfall occurred north of Franklin at Cooperstown in an area of gentle to moderate slopes, but no mass movement was reported from this area.

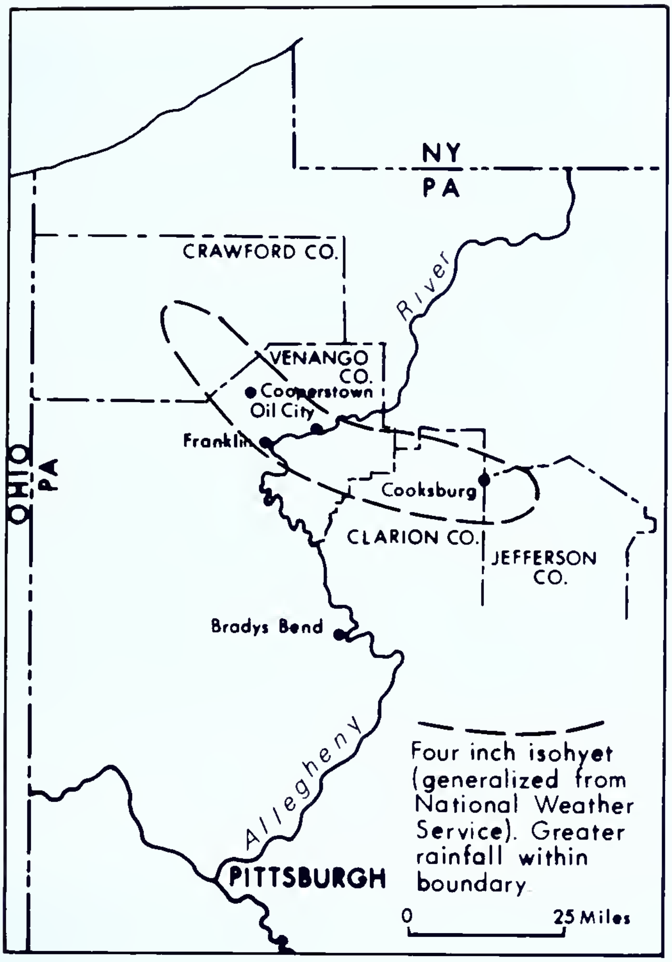


Fig. 1 Map showing area of major rainfall June 9, 1981, northwestern Pennsylvania.

The overall sparsity of landslides can be attributed to the generally well-drained sandy mantle derived from the Pottsville and Allegheny Groups of Pennsylvanian age and glacial deposits derived from these bedrock units. Only along the lower slopes cut by the Allegheny River is there an increase in silty to clayey material derived from the underlying (older) rocks of the Shenango Formation and Cuyahoga Group of Mississippian age. Also, a significantly greater thickness of loose rock and soil exists on these slopes than on those in the adjacent less deeply incised tributary drainages.

One noteworthy storm-induced landslide is located above a parking lot about 0.5 mile east of the Allegheny River-French Creek confluence at Franklin and north of U.S. 62. The slide, consisting of loose rock and soil, is 240 feet wide at its base and extends 90 feet vertically to a head scarp which is about 12 feet high (Figures 2, 3). The slope averages slightly more than 30° (58 percent). Initial move-

Fig. 2 Base of colluvial slide. Parking lot previously had been covered by soil and rock debris.

Fig. 3 View of slide looking upslope from parking lot. Note scale in front of head (A). B is foot of slide.

ment took place a few days after the storm, according to the plant manager and Lyle Cathcart (U.S. Soil Conservation Service, Franklin). The slide mass spread out over the parking lot to within a short distance of the building, necessitating the removal of the slide at the toe. Trees standing on the slide mass were cut to lighten the load on the unstable slope.

The importance of a single intense storm in initiating mass movement cannot be overstated. For example, climatic records between June 1 and August 4, 1980 (U.S. National Weather Service, written commun., 1980) at Franklin reveal a rainfall of more than 20 inches which is well above normal; however, no single day's total exceeded 2.8 inches. No significant landsliding is known to have taken place.

Flash flooding and accompanying local slope movements have plagued many parts of western Pennsylvania in recent years. Landsliding took place in the Johnstown area in mid-1977 during and after an intense 8- to 12-inch rain (Pomeroy, 1980b). In addition to the 1980 Brady's Bend storm and 1981's flash flooding in northwestern Pennsylvania, many parts of Greene County and southern Washington County in extreme southwestern Pennsylvania have been subject to record rains during the past two years.

On September 2, 1981 the Johnstown area was hit by another storm which caused flooding south and west of the town. Slightly more than 5 inches fell within 3 hours in a region which had not received the brunt of the 1977 storm. However, neither the Pennsylvania Geological Survey office in Pittsburgh (Helen Delano, written commun., 1981) nor the writer received any reports of landsliding.

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NEW STAFF MEMBERS

HELEN L. DELANO joined the staff of the Bureau of Topographic and Geologic Survey as the Environmental Geologist assigned to western Pennsylvania in the fall of 1980. Her office is in Pittsburgh at the Survey quarters in the Kossman Building. Her duties include assisting individuals and planning agencies on questions dealing with landslides and other geologic hazards, groundwater, engineering characteristics of the rocks of western Pennsylvania, and general information on the geologic environment.

Helen received a B.S. in Geology from Tufts University in 1974 and an M.A. in Geological Sciences in 1979 from the State University of New York at Binghamton. At SUNY she concentrated in environmental geology, geomorphology and sedimentology. From graduation until she joined the Survey, Helen was project geologist and crew chief for the National Park Service's archaeological survey of the Cape Cod National Seashore.

Helen is a member of the Geological Society of America, Society of Economic Paleontologists and Mineralogists and the Pittsburgh Geological Society.

CHARLES G. EISIMINGER, who comes from Monongahela in Washington County, is now a part of the Survey's Oil and Gas Inspection Team.

He went to work for Peoples Gas Company in 1959 where he learned the drilling and operating procedures of oil and gas wells. In 1961 he joined the U.S.A.F. Upon being discharged in 1969, he returned to Pennsylvania and went back to work for Peoples Gas in the production and drilling field.

He joined the Survey's Division of Oil and Gas Regulation, as an Oil and Gas Inspector on November 23, 1981.

DAVID W. FORD began employment as an Oil and Gas Inspector on September 24, 1981, with the Division of Oil & Gas Regulation.

David, who is a native of Smethport, Pennsylvania has had extensive field experience in areas such as drilling, plugging, cleaning out and Hydro-fracking. Working throughout northwestern Pennsylvania, eastern Ohio, Tennessee and New York State. From October 1978 thru August 1981 he did contracting work for National Fuel Gas Supply Corporation.

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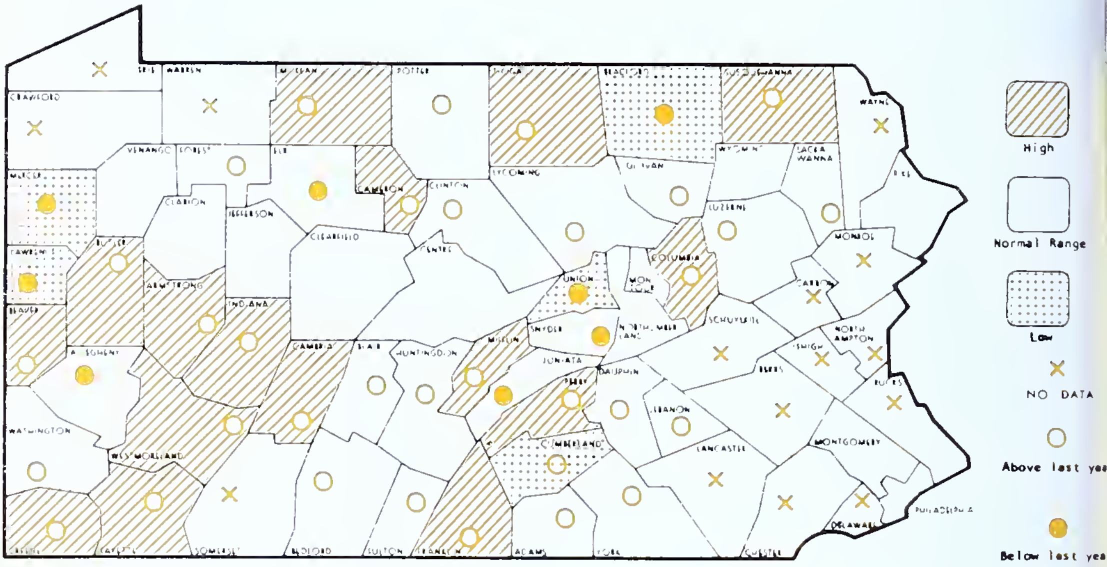
GROUND WATER LEVELS

FOR

February 1982



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PENNSYLVANIA GEOLOGY

THE PENNSYLVANIA GEOLOGICAL SURVEY

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Richard L. Thornburgh, Governor

DEPARTMENT OF ENVIRONMENTAL RESOURCES
Peter S. Duncan, Secretary

OFFICE OF RESOURCES MANAGEMENT
R. Timothy Weston, Associate Deputy Secretary

TOPOGRAPHIC AND GEOLOGICAL SURVEY
Arthur A. Socolow, State Geologist

CONTENTS

ON THE COVER: Shohola Falls, Pike County. Shohola Creek descends 200 feet in a half mile of falls and rapids over shales and sandstones of the Catskill Formation of Devonian Age. State Game Land 180 surrounds and includes the falls.

PENNSYLVANIA GEOLOGY is published bimonthly by the Topographic and Geologic Survey, Pennsylvania Dept. of Environmental Resources, Harrisburg, Pennsylvania, 17120.

Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

June 1982

FROM THE DESK
OF THE
STATE GEOLOGIST . . .

FROM ACROSS THE NATION, THE STATE GEOLOGISTS

We are very privileged to be serving as host to the 74th Annual Meeting of the Association of American State Geologists this year at Hershey on June 6 to 10. This group, whose membership consists of the 50 State Geologists across the country, meets each year in a different state to discuss new developments and procedures of common interest and benefit to all. Federal programs and cooperative activities are regularly reviewed, particularly appropriate in light of the changes now taking place.

What is a State Geologist? He (and now we welcome the first "she" State Geologist from Utah) is commonly the Director of the State Geologic Survey of the respective state — although the title of the unit varies somewhat from state to state. Basically the State Geologist is responsible for heading up a complex program which identifies and evaluates the geologic conditions and geologic resources of the state, with emphasis on serving the geologic needs of the citizens of the state. In some states this may also involve regulatory responsibilities over activities such as oil and gas drilling, water wells, and mining.

The State Geologist, thus, serves at the interface between scientific investigation of geologic matters and the public need to cope with geologic issues. The issues may include geologic hazards (landslides, earthquakes), mineral resources needs to keep industry operating (coal, limestone, iron ore, clay), or identifying the local geology in order to plan and construct highways, dams, sewage systems, or recreation facilities. State Geologists, therefore, do not enjoy the luxury of "ivory tower" positions, but rather must be accessible and attuned to respond promptly to a multitude of needs, be they from fellow government agencies, industry, schools, or the general public.

The ever-growing awareness of the role of geology in our society, including the lessons of energy and mineral shortages which have been thrust upon us, as well as the environmental impacts of natural geologic hazards and man-made engineering problems, all serve to provide for State Geologists a claim that each can share: there is never a dull moment.

So we welcome to Pennsylvania the State Geologists from across the nation and trust that their meeting and their sampling of Pennsylvania geology and hospitality will be productive, pleasant, and memorable.

Arthur A. Socolow

$ 8 Billion lost yearly from geologic and hydrologic hazards

Geologic and hydrologic hazards, such as earthquakes, floods, ground failures and volcanic eruptions, now cause an estimated $8 billion in losses annually in the United States. However, these losses can be greatly reduced, according to a new report by the U.S. Geological Survey. "Facing Geologic and Hydrologic Hazards—Earth-Science Considerations," describes the physical characteristics of geologic and hydrologic hazards, identifies the locations in the United States where these hazards tend to happen, specifies their impact on the nation's people, buildings, structures, and economy, and discusses actions that can reduce losses in lives and property.

The report is designed to provide basic earth science information that can be used by planners and decisionmakers in taking actions to reduce losses from geologic and hydrologic hazards.

The USGS report suggests a variety of possible actions designed to reduce losses from geologic and hydrologic hazards including:

* Avoiding the hazard by selecting other appropriate areas in which to live or reducing the hazard by building where the probability of the hazard's occurrence is lowest.
* Zoning or planning within an area characterized by a relatively high probability of occurrence of the hazard to reduce building density or prohibit certain types of structures susceptible to a particular type of hazard.
* Allowing all types of structures within a potentially hazardous area, but requiring site-specific engineering design and construction to increase the capability of the site or structure to withstand the hazard.
* Distributing the potential losses through insurance and other financial methods.

The report says that both average annual losses and the potential for sudden great losses have increased and will continue to do so fairly rapidly for several reasons, including:

* More and more people are living in flood-prone areas, areas of high seismic risk, exposed coastal locations, landslide prone areas and near potentially active volcanoes;

* Urban centers are growing annually through construction of homes, schools, hospitals, high-rise buildings, factories, utility systems, dams, oil refineries, airports, and other facilities. This growth causes additional high-value property to be exposed to geologic and hydrologic hazards every year.

The report points out that making decisions and taking actions designed to reduce losses is especially difficult because of the technical nature of the earth-science information that must be considered and because of the uncertain times and places where these hazards may occur and the great variation in the magnitude and probability of occurrence.

Some highlights from the report include:

* A repeat of the 1906 San Francisco, Calif., earthquake, which took 700 lives and destroyed buildings costing, in 1978 dollars, about $170 million, probably would cause $24 billion in damages now and, depending on the time of day, take about 5,000 lives and cause 700,000 injuries.
* If a similar large-magnitude earthquake occurred in the Los Angeles area, it would probably cause losses of about $45 billion and as many as 23,000 deaths.
* A repeat of the New Madrid, Mo., earthquakes of 1811-1812, estimated by many to have been the most violent series of earthquakes in the United States, could cause losses in the Midwest comparable with the "worst case" estimates for San Francisco or Los Angeles.
* The annual loss from floods in the United States has increased from $100,000 (in current dollars) at the beginning of the century to more than $3 billion today. More than 20,800 communities have flood problems and of those, about 6,100 have populations greater than 2,500.
* Direct and indirect damage from landslides in the United States totals more than $1 billion per year. An average of 25 lives are lost from landsliding each year.
* Expansive soils—soil and soft rock which tend to swell or shrink due to changes in moisture content—cause from $2 to $7 billion in damage annually. Of the more than 250,000 new homes built annually on expansive soils in the United States, 10 percent undergo significant damage and 60 percent undergo minor damage.
* Volcanic eruptions occur relatively infrequently, but they cannot be ignored. Eruptions have a significant short-term impact,

as the 1980 Mount St. Helens eruptions have shown. The total cost of these eruptions is expected to reach $2-3 billion.

Copies of the 110-page USGS Professional Paper 1240-B, "Facing Geologic and Hydrologic Hazards—Earth Science Considerations," illustrated with over 100 maps and color photographs, may be obtained for $7.50 each from the Branch of Distribution, U.S. Geological Survey, 1200 South Eads St., Arlington, VA 22202. Orders must specify the professional paper number and include check or money order payable to the U.S. Geological Survey.

"CULPRIT" MINERALS MAY HINDER GAS PRODUCTION IN BLACK SHALES

by John H. Barnes
Pa. Geological Survey

In recent years, the Pennsylvania Geological Survey has participated in studies of the potential of black shales as sources of natural gas (see Piotrowski, 1978 and Harper, 1980). While most shales in Pennsylvania have until recently been little-explored for natural gas, one that has been a proven producer since the very dawn of this industry is the Dunkirk shale facies of the Devonian "Canadaway Group" (Piotrowski and Harper, 1979). It was into this shale that the Nation's first gas well was drilled in 1821 at Fredonia, New York, only 30 miles outside of Pennsylvania. Numerous small wells still feed gas from the Dunkirk shale to individual homes and factories in Erie County.

Two of the wells recently drilled into this shale in Erie County (Fig. 1) provided illustration of a manner in which the mineralogy of the shale can affect production. The first of these wells, Welch Foods #3, was drilled to a depth of 900 feet near the borough of

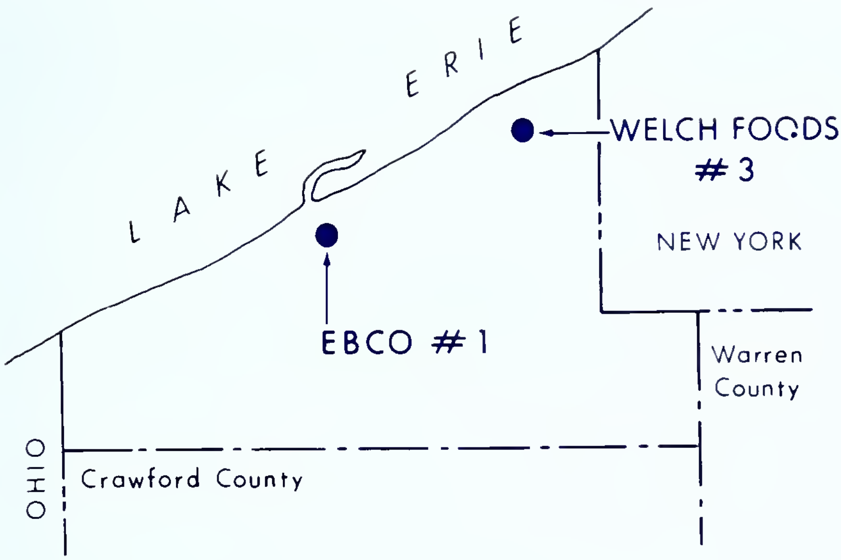

Figure 1. Map of Erie County showing locations of EBCO #1 and Welch Foods #3 wells. (after Piotrowski and Harper, 1979).

North East. A natural open-flow rate of 12,000 cubic feet/day was initially reported. In an attempt to increase flow, the well was "stimulated" by "foam-water fracturing", a process that basically involves pumping liquids into the well under high pressure to force open fractures in the rock and allow the gas to flow out more easily. After this was done, the flow increased to 150,000 cubic feet/day temporarily, but after a month it had decreased to 3,500 cubic feet/day. At this low level, the company did not consider it economically feasible to lay a pipeline to their plant, and the well is out of production (Piotrowski and Harper, 1979; Harper, 1980).

The second well, EBCO #1, was drilled to 901 feet in the city of Erie for the Erie Burial Case Company. This well encountered three significant shows of gas with a total initial potential in excess of 3,000,000 cubic feet/day; however, the flow rate later dropped to 975,000 cubic feet/day. As a result of this high flow rate, apparently caused by a natural system of fractures, stimulation was not necessary, and today the well is supplying the fuel needs of the EBCO plant. (Piotrowski and Harper, 1979; Harper and Piotrowski, 1978).

Because of the problems encountered with the Welch Foods #3 well and other wells in Devonian black shales in which foam-water fracturing was used, samples of cuttings from the successful EBCO well were submitted to the Survey's Mineral Resources Division for

study. As part of our routine procedure for study of rock, the samples were scanned by X-ray diffraction, a technique which helps to identify the minerals that are present in the rock. Among the minerals typically found in shale, evidence was found to suggest the presence of minerals that belong to the smectite group (sometimes called the montmorillonite group).

Smectite is a clay mineral and, like other clay minerals, is composed of flat layers of molecules. The familiar minerals mica and vermiculite also have this structure, which gives them their characteristic platy habit. In clays, including smectite, however, the plates are too small to be seen without the great magnification of an electron microscope.

The unique feature of the smectites that sets them apart from other clay minerals is that the layers of molecules are only very loosely bound together. Because of this, smaller molecules, such as water molecules, can enter the space between the smectite layers and push them apart (Fig. 2) (Grim, 1968). This effect can be tested and observed via a standard procedure with the X-ray diffraction equipment, which measures the distance between layers of molecules. A sample from the EBCO well was divided into three sub-samples: one was heated to a high temperature to drive off any water, a second contained water between the smectite layers, a third was placed in an atmosphere of ethylene glycol, which pushes the layers even farther apart than water. When the three sub-samples were X-rayed (Fig. 3), the one which contained interlayer water and the glycol-treated one showed a lower peak height (A) and a higher background (B) than the dehydrated sub-sample, characteristic of samples containing smectite. These sub-samples also

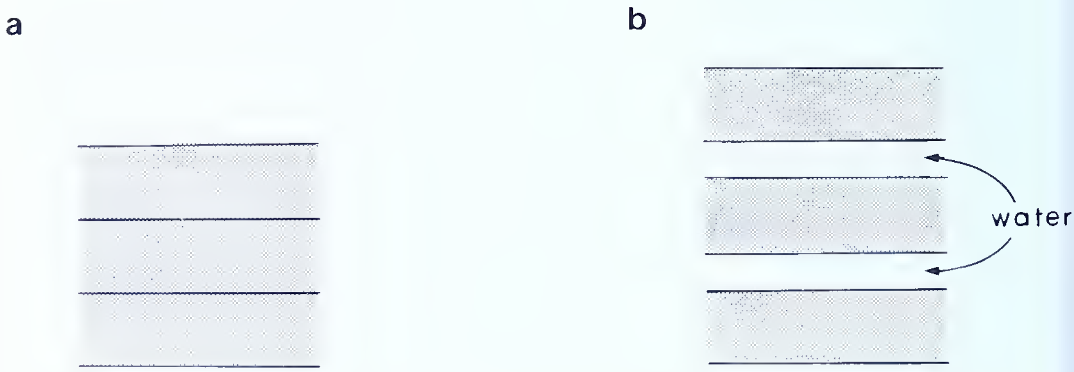

Figure 2. Simplified diagram of the structure of smectite (a) unexpanded, in its dehydrated form, and (b) expanded by interlayer water.

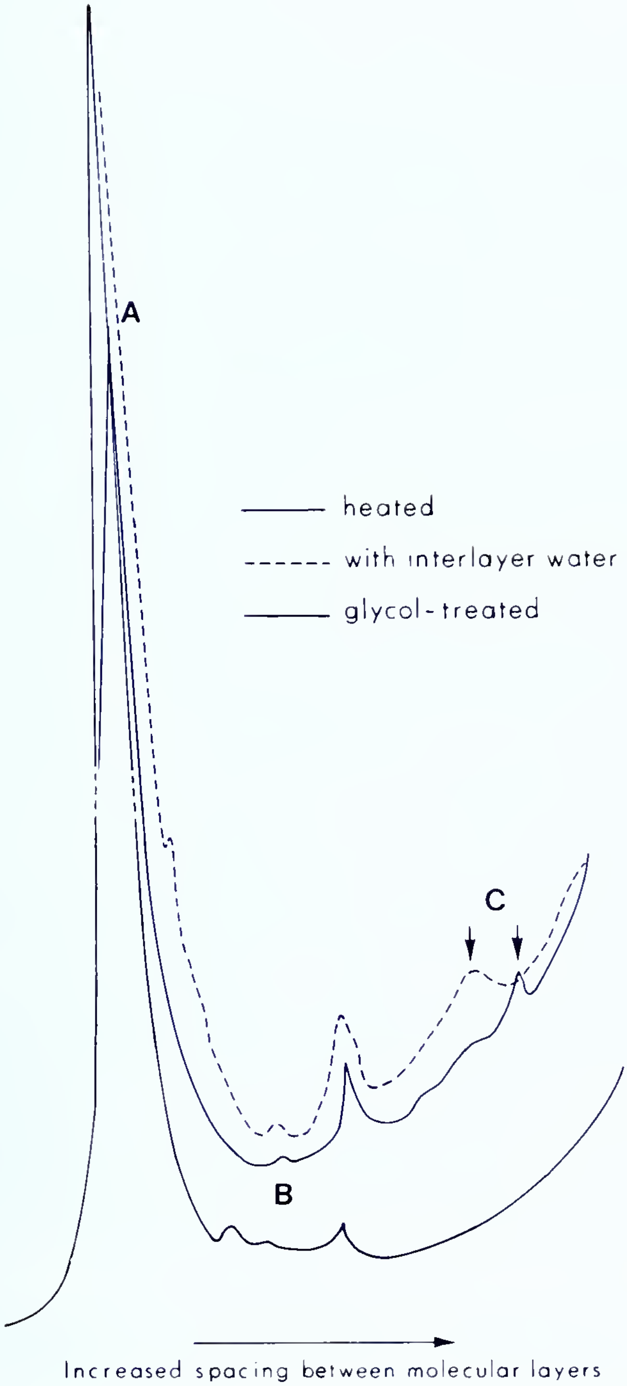

Figure 3. X-ray diffraction patterns of sample from EBCO #1. Water-bearing and glycol-treated show asymetry on right side of peak and lower peak height (A), and high background to the right (B), suggestive of smectite-bearing material. Note the characteristic shift in the position of one high-spacing peak (arrows) (C), typical of smectite when glycol-treated.

showed a peak (C) that was missing in the heated sub-sample and that was displaced to a larger spacing in the glycol-treated sub-sample (see arrows in Figure 3). This confirms the presence of material that includes an expandable smectite.

One explanation, then, as to the cause of the drastic reduction in flow of the Welch Foods #3 well is that the fluids that were injected into the ground to open up the rock and allow greater flow actually expanded the smectite, which closed up the fractures and pores in the rock tighter than before, shutting off most flow. Prior to this rather routine X-ray text at the Pennsylvania Survey, the presence of smectite in the Devonian black shales of Pennsylvania was unreported. Later tests by the U.S. Geological Survey have shown this mineral to be a common constituent of black shales (Hosterman and Whitlow, 1981), and have shown the need for some different method of stimulation of gas wells in these formations (Harper, 1980).

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Out of print geologic reports available

The Pennsylvania Survey has accumulated various surplus publications. We are making them available to college libraries and earth science departments, and to interested individuals as supplies permit. If you are interested, contact Arthur Socolow, State Geologist, Pennsylvania Geologic Survey, P.O. Box 2357, Harrisburg, PA 17120.

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C6	Philadelphia, Montgomery and Bucks Counties	1882
D	Lehigh County iron mines	1875
D2	Lehigh County iron mines	1878
D3	Vol. 1 Lehigh and Northampton Counties	1883
D3	Vol. 2 Berks County	1883
E	Trap dykes and Azoic Rocks of SE Pa.	1878
F	Juniata River district, Mifflin, Snyder, Huntingdon Counties	1878

FF	Perry County	1884
F3	Union, Snyder, Mifflin and Juniata Counties	1891
G	Bradford and Tioga Counties	1878
GG	Lycoming and Sullivan Counties	1880
G3	Potter County	1880
G4	Clinton County	1880
G5	Susquehanna and Wayne Counties	1881
G6	Pike and Monroe Counties	1882
G7	Wyoming, Lackawanna, Luzerne, Columbia, Montour and Northumberland Counties	1883
H	Clearfield and Jefferson Counties	1875
HH	Cambria County	1877
H3	Somerset County	1877
H4	Indiana County	1878
H5	Armstrong County	1880
H6	Jefferson County	1881
H7	Clearfield County	1884
I	Venango County	1875
II	Oil well records, Venango, Warren, Crawford, Clarion, Armstrong, Butler Counties	1877
I3	Venango, Warren, Clarion and Butler Oil Regions	1880
I4	Warren County	1883
I5	Oil and gas fields	1890
J	Oil Region	1875
K	Greene and Washington Counties	1876
K2	Fayette, Westmoreland and Allegheny Counties	1877
K3	Fayette and Westmoreland Counties	1878
K4	Monongahela River Coal Mines	1884
L	Youghiogheny coke manufacture	1876
M	Chemical Analyses 1874-5	1875
MM	Chemical Analyses 1876-8	1879
M3	Chemical Analyses 1879-80	1881
N	Levels above tide of railroads, canals, etc.	1878
O	Specimens collected by the Survey	1878
P	Coal flora	1880
PP	Permo-Carboniferous plants	1880
P3	Ceratiocaridoe	1884
P4	Dictionary of fossils	1889
Q	Beaver, Allegheny and Butler Counties	1878
QQ	Lawrence County	1879
Q3	Mercer County	1880
Q4	Crawford and Erie Counties	1881
R	McKean County	1880
RR	Cameron, Elk and Forest Counties	1884
T	Blair County	1881
TT	Bedford and Fulton Counties	1882
T3	Huntingdon County	1885
T4	Centre County	1884
V	Butler County	1879
V2	Clarion County	1880

Subsurface faulting in McKean County – a "textbook" example

by Christopher D. Laughrey
Pa. Geological Survey

An unusually good example of subsurface faulting is demonstrated on the geophysical log of the Amoco Production Company's #1 Mars Company gas well in McKean County. The well is located on the Hazel Hurst 7-½ minute quadrangle in Sergeant Township. The well was completed on July 31, 1974, as a shallow extension of the Hazel Hurst field. Total depth is 6,160 feet. The deep formations were found to be dry, but the Upper Devonian Bradford Group sandstones were evaluated as potentially productive and pipe was set at 2,608 feet.

The fault zone is recognizable on the geophysical log between 5,920 and 5,926 feet (Figure 1). The Middle Devonian Onondaga Group occurs from 5,875 to 5,920 feet. This stratigraphic interval is then repeated between 5,926 and 5,976 feet. This repetition can be seen in the signatures of the gamma-ray and neutron porosity logs.

The gamma-ray log is an indicator of the shaliness of the formation and is used for subsurface correlation. Shales, siltstones and clays have a relatively high concentration of natural radioactivity whereas sandstones and limestones are usually low in radioactivity. The gamma-rays emitted from the formation are detected using a Geiger-Mueller or a scintillation instrument. When the gamma-ray log passes through sandstone or limestone, the line shifts to the left. When the log encounters shale, clay or siltstone, the line shifts to the right. The gamma-ray log illustrated in figure 1 exhibits a nearly perfect repetition of the four Onondaga Group members across the indicated fault zone.

The neutron log is basically considered a porosity tool. The neutron device emits high energy neutrons from a radioactive source. When the neutrons encounter hydrogen nuclei in the formation in the form of water or oil, the neutrons are absorbed. The detector will

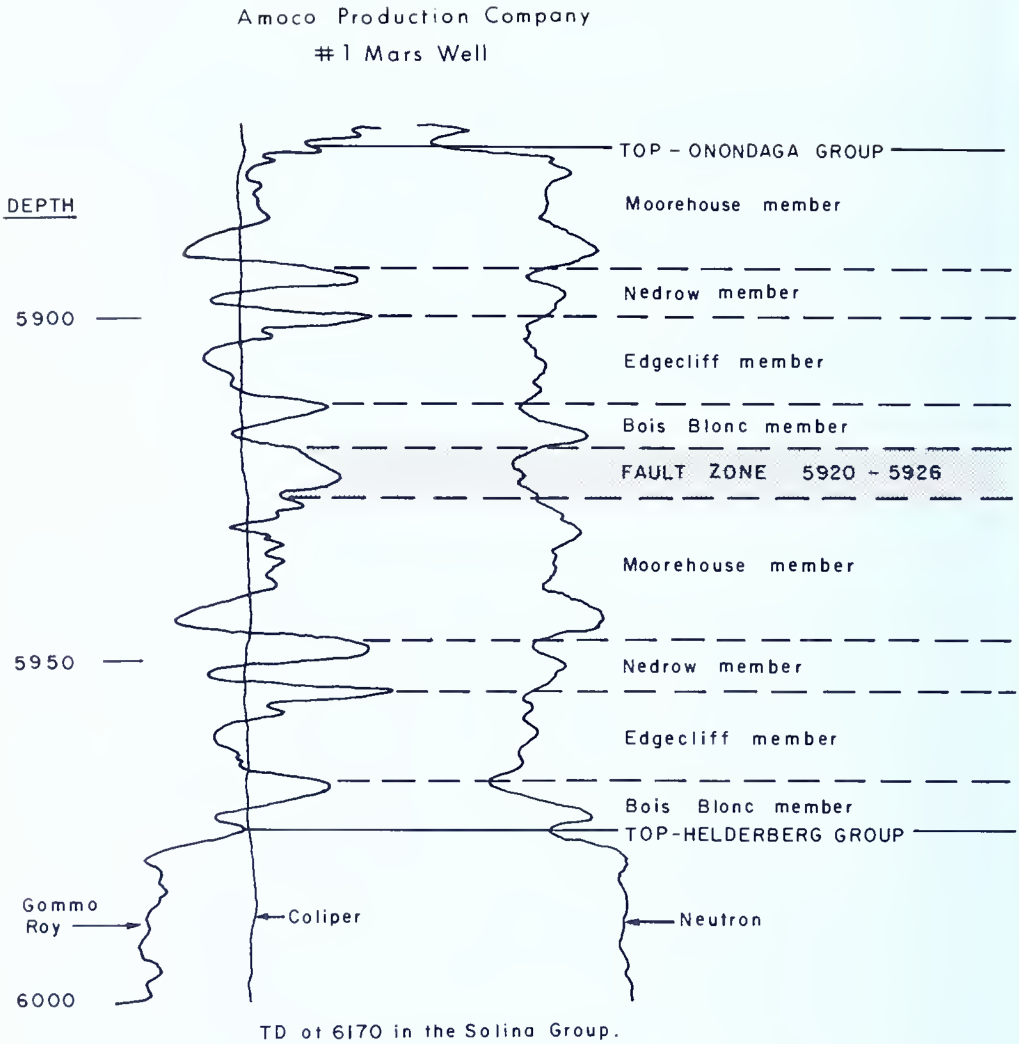


Figure 1. Geophysical log of the #1 Mars gas well. The gamma-ray and neutron log signature of the Onondaga Group is from 5,875 to 5,920 feet. This signature is repeated from 5,926 to 5,976 feet. Fault zone is implied from 5,920-5,926 feet.

show a low radioactive reading since there are few neutrons that will return to the borehole. Therefore, the neutron measures the liquid filled porosity of a formation. In figure 1, the neutron log shift is to the right (low hydrogen) when the log encounters limestone members of the Onondaga Group (gamma-ray shifts to the left). This indicates that the Moorehouse, Nedrow, Edgecliff and Bois Blanc members are dense, non-porous limestones. The same neutron log pattern is repeated across the fault zone.

Figure 1 also shows the caliper log. The caliper measures hole diameter and it can indicate wash-out sections in the formations. The caliper log in figure 1 indicates a rather constant, undisturbed hole

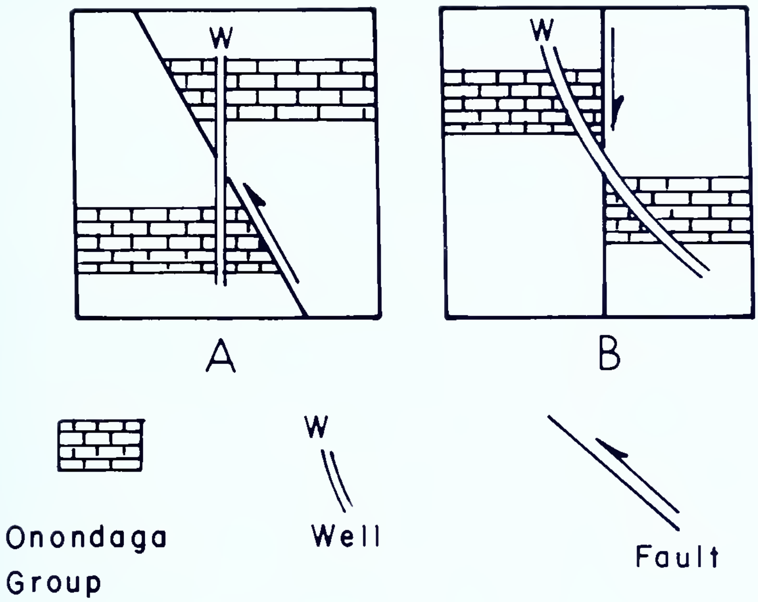


Figure 2. Two possible geologic conditions that could account for the repetition of beds illustrated in Figure 1.
A. Reverse faulting.
B. Vertical Fault — repetition of beds due to deflection of the borehole.

diameter across the fault zone. This indicates that any fractures formed during the faulting episode were subsequently filled with mineral cement. Together, the three logs shown in figure 1 represent an uneconomical zone in this particular well.

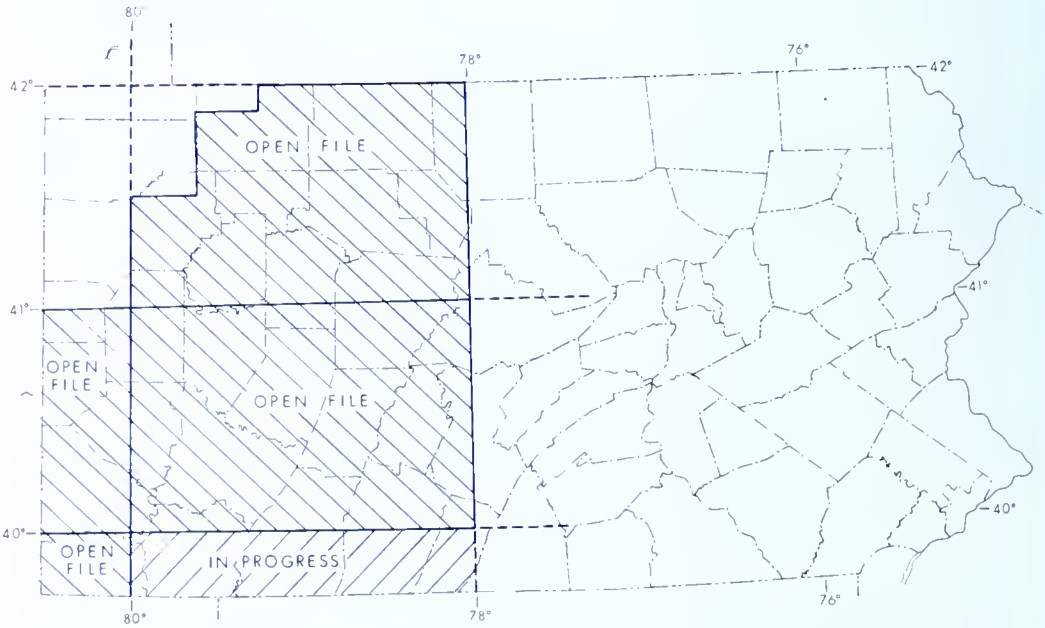
Repeated beds are usually diagnostic of reverse or thrust faults. However, it is important to consider that a borehole might be deflected by a vertical fault and show an apparently repeated section (Figure 2). Experience in this portion of McKean County indicates that the #1 Mars well probably penetrated a thrust fault on the east limb of the Smethport anticline.

Log signatures are generally somewhat ambiguous across fault zones. It usually requires a good deal of experience and some imagination to recognize repeated beds on geophysical logs. The fault shown on the #1 Mars well log is undoubtedly a "textbook" example.

LANDSLIDES IN WESTERN PENNSYLVANIA

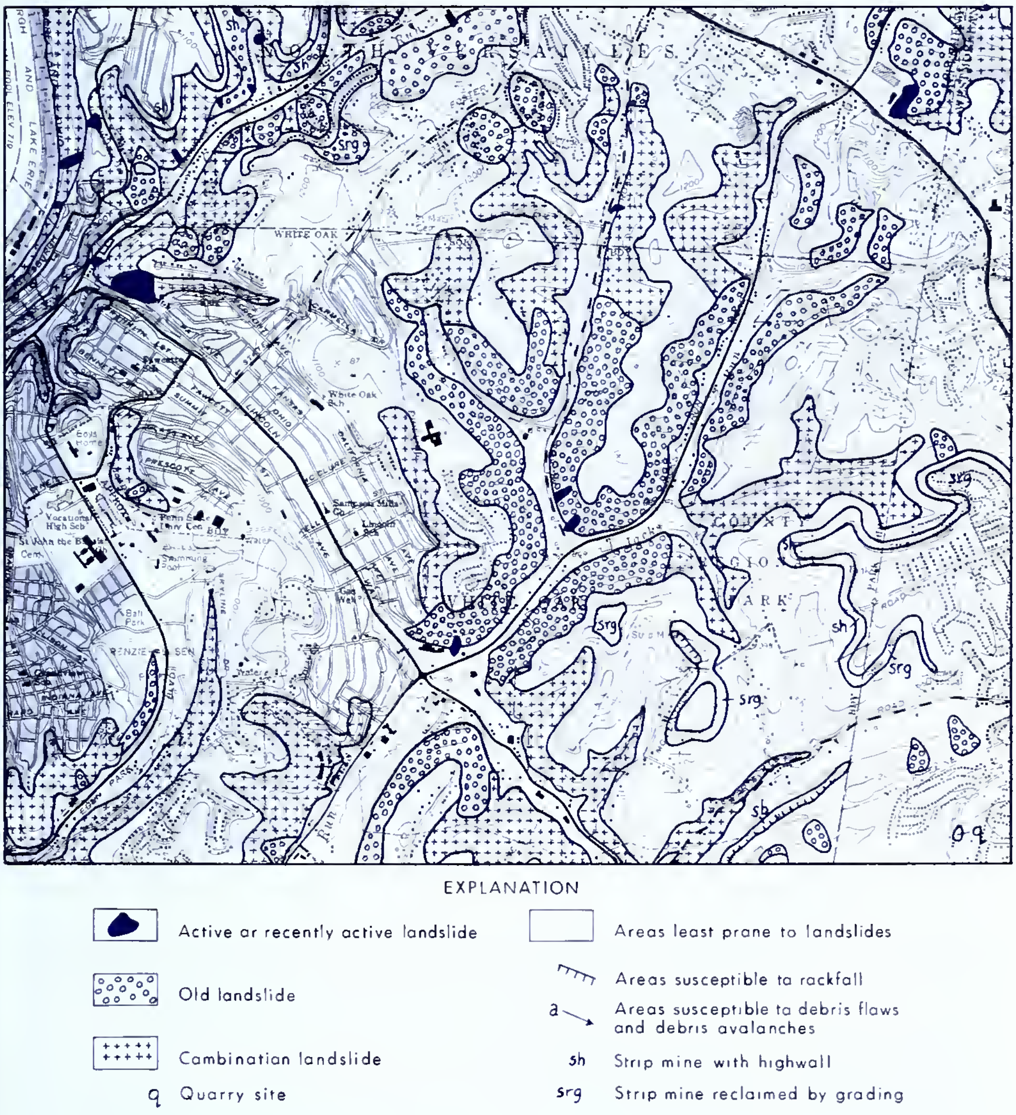
A set of maps showing landslides and related features for most of western Pennsylvania has been prepared by the U.S. Geological Survey and released on open file. Areas covered by these maps are shown on the accompanying index map. The maps are on 7½-minute quadrangle bases (1:24,000 scale) and show active or recently active landslides, old landslides, several categories of slopes susceptible to sliding, areas susceptible to rockfall, and a number of man-made features such as strip mines and coal refuse banks. Information shown on the maps was gathered primarily by air photo interpretation and supplemented by field checking and reference to historical records.

This information is potentially useful to planners, developers and engineers as an aid in predicting slope stability conditions. The maps cannot substitute for detailed geologic and engineering investigations of a specific site, but can be used as a general guide to ground conditions for planning purposes and to indicate areas requiring more detailed investigations.



Location of open file maps

John S. Pomeroy, William E. Davies, Gregory C. Ohlmacher and Robert Hackman of the U.S.G.S prepared the maps, which are on file in the U.S.G.S. library in Reston, Virginia and at the Pennsylvania Bureau of Topographic and Geologic Survey offices in Harrisburg and Pittsburgh. The maps are available for examination and review at the bureau offices and may be copied from mylar originals at the user's expense.



Example of landslide mapping from open file map. Not all of the map symbols are shown in this example.

Richard F. Walther
25 years of service

Richard F. Walther, Geologist, Division of Oil and Gas Regulation, Bureau of Topographic & Geologic Survey, has celebrated his 25th anniversary of his employment with the Commonwealth of Pennsylvania.

Dick started his career with the Oil and Gas Division, Department of Mines and Mineral Industries, on February 27, 1957, as an Oil and Gas Inspector. In March 1957 he established the Pittsburgh Field Office of the Division under the direction of W. Roy Cunningham, Deputy Secretary of the Mines and Mineral Industries, which he maintained until the complete Oil and Gas Division moved to Pittsburgh in September 1963.

At various times during his tenure as Oil and Gas Inspector (1957-1979), he was the inspector for the following counties: Allegheny, Armstrong, Beaver, Butler, Cambria, Indiana, Lawrence, Mercer and Westmoreland. His duties included regulating drilling, plugging and underground gas storage reservoirs.

In September 1979, Dick was designated to work in the Natural Gas Policy Act Section. After working in that section for more than a year, he moved on to work in the Permit Section of Oil and Gas Regulation, reviewing all coal locations, well pillar applications and gas storage information.

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In Cooperation with The U.S. Geological Survey

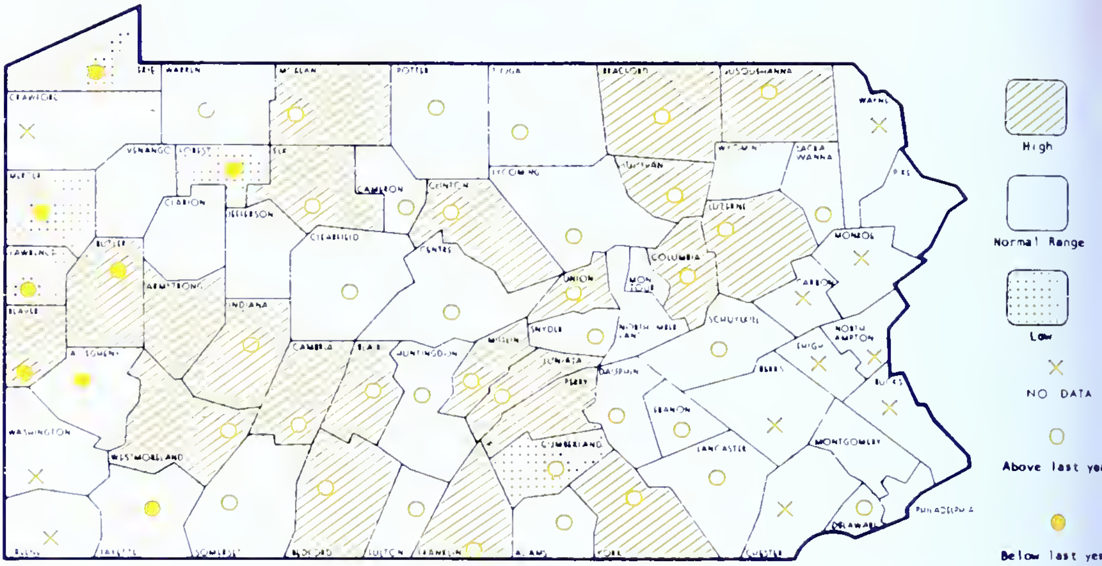
GROUND WATER DIVISION

In Cooperation with The U.S. Geological Survey

GROUND WATER LEVELS

FOR

April 1982



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PENNSYLVANIA GEOLOGY

COMMONWEALTH OF PENNSYLVANIA
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OFFICE OF RESOURCES MANAGEMENT
R. Timothy Weston, Associate Deputy Secretary

TOPOGRAPHIC AND GEOLOGICAL SURVEY
Arthur A. Socolow, State Geologist

CONTENTS

ON THE COVER: Big Spring in Washington Township, Franklin County; along Marsh Run, .55 miles north of Maryland line. Spring is along a fault contact in the Shadygrove limestone; measured flow is 2500 gpm.

PENNSYLVANIA GEOLOGY is published bimonthly by the Topographic and Geologic Survey, Pennsylvania Dept. of Environmental Resources, Harrisburg, Pennsylvania, 17120.

Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

August 1982

FROM THE DESK
OF THE
STATE GEOLOGIST

TWO DIFFERENT ANSWERS AREN'T ALL BAD

Science is generally considered synonymous with accuracy. Scientists are expected to provide answers that can be relied upon. The public expects it. To say "It is a scientific fact" is the ultimate truth!—or is it?

In the current issue of the journal American Scientist is an article entitled "Late Cretaceous Extinctions" which purports to prove that the well reknowned event in geologic history when so many vertebrate and invertebrate life forms went into extinction was really a product of gradual process, rather than a sudden catastrophic event. Yet earlier this year, other highly respected geoscientists at the AAAS meeting in Washington gave several convincing talks, one "proving" that the extinction event was due to the impact of a large meteor, and another "proving" that the extinction phenomenon was due to massive volcanic eruptions which affected the atmosphere and the ocean water quality. All of these scientists are capable, respected researchers, each dealing with the same starting set of known facts.

There are many, many other examples of scientists who arrive at differing conclusions. Some issues of unsolved scientific diversity includes the origin of our moon and our solar system, the origin of life itself, the degree to which living organisms can tolerate low-level radiation, etc.

Sometimes scientific divergence moves from the labs and campuses into the courtroom where both sides of a case may call in scientists as expert witnesses, and with the same set of facts the scientists present opposing conclusions. In so doing neither of the scientific witnesses is either lying nor incompetent.

Differing scientific conclusions are a tribute to the very creative and democratic strength of the scientific process in the ability not to be dogmatic, but rather the freedom to assess and to reassess data and evidence, and the willingness to accept new interpretations and new conclusions brought about by new evidence or newly inspired interpretations.

So if you find two geologists who have arrived at differing conclusions, don't despair. They may not both be right, or they may both be partially right. But they are practitioners of the process of hypothesizing, researching and data collecting, analysis and interpretation, followed by conclusions. The strength of science and scientists is that they are not inflexible or dogmatic, that they reflect the almost unending creative capabilities of the human mind.

Arthur A. Socolow

Reorganization Effect On Geologic Survey

Just as we are going to press with this issue, it has been formally announced that effective August 9th our Division of Oil and Gas Regulation in Pittsburgh will become a separate bureau and will be transferred to a newly created Office of Environmental Energy Management within the Deputate for Environmental Protection headed by Deputy Secretary William B. Middendorf. Other bureaus under the Office of Environmental Energy Management will be Deep Mine Safety, Mining and Reclamation, and Radiation Protection.

Within the Deputate for Environmental Protection there is also being created an Office of Environmental Management, under which will operate the Bureaus of Air Quality Control, Community Environmental Control, Solid Waste Management, Water Quality Management, and Laboratories.

The Division of Oil and Gas Geology in Pittsburgh will remain as a division of our Bureau of Topographic and Geologic Survey. Our Survey continues as a bureau within the Deputate of Resources Management.

Measuring the nation - past and present

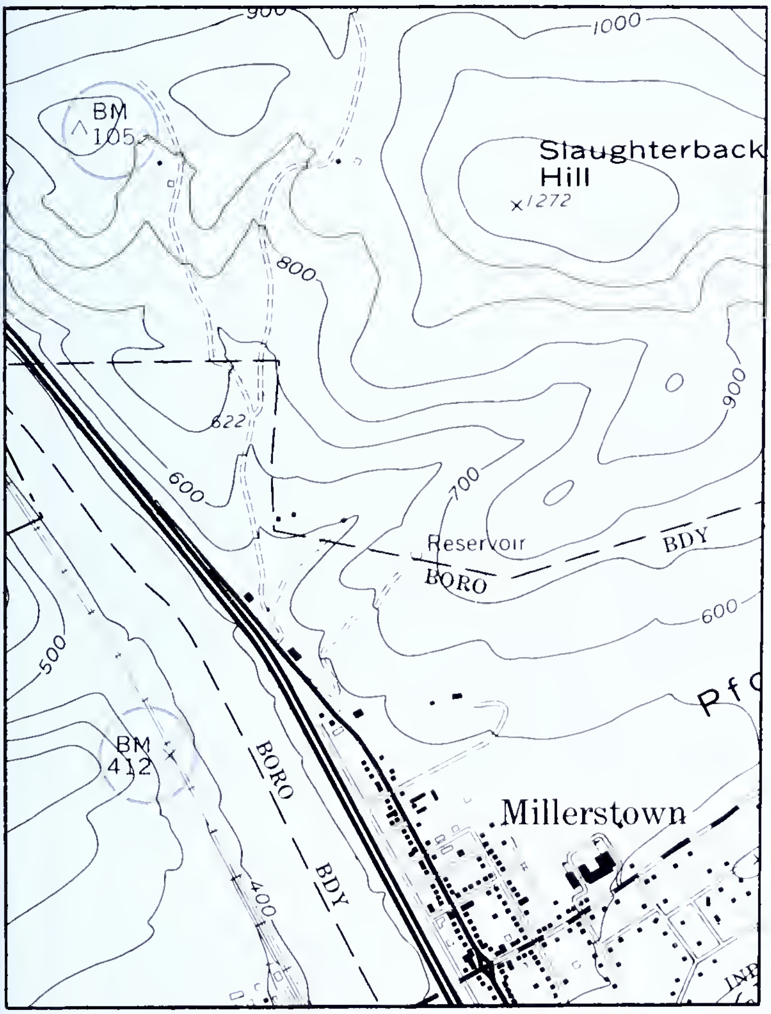
Some experts know the highest and lowest elevations in the 48 conterminous United States and the highest and lowest elevations in Pennsylvania, but how many people know how these elevations were established? How many people know how a surveyor can say a monument near Millerstown, Pennsylvania, is located precisely at latitude 40°37′04.6130″N and 77°10′00.6663″W longitude and is at elevation 1057.848 feet?

The horizontal position (the latitude and longitude) of a point and altitude above sea level (elevation) are some of the most significant information depicted by a map. This information locates the site in relation to all other places in the United States, and is called "geodetic control data".

The data for a horizontal control point consist of the latitude and longitude of the control mark, and a description of the mark. The data for a vertical control point consist of the elevation of the mark and a description of its location.

The entire country is covered with a network of geodetic control points. The control points are indicated by bronze markers or tablets which have been set in the ground. The horizontal control markers are called monuments, and the vertical markers are called bench marks. The markers may be found in varied places: the tops of remote mountains, and sidewalks of large cities. The monument northwest of Millerstown is also a bench mark. A bench mark at elevation 412 feet is due west of Millerstown.

Geodetic control data are the basis for U.S.G.S. topographic maps. Every map includes horizontal markers and vertical bench marks that exist in the area covered by the map.



EXPLANATION

△ **Monument**

× **Benchmark**

Portion of the Millerstown, Pa., topographic map showing monuments and bench marks

The Department of the Treasury was assigned the task of making a survey of the entire coast of the United States in 1807. A world renouned Swiss scientist, Ferdinand Rudolph Hassler, directed the field work. Hassler's work produced the first systematic approach to surveying the country and establishing a geodetic system that could be extended nationwide. A network of horizontal control data points was developed and came to be known as the North American datum 1927.

A similar study of elevations was undertaken at about the same time and is known as the National Geodetic Vertical Datum 1929. It is still in use, as is the North American Datum 1927.

Because of natural and man induced ground movements, as well as the disruption of certain monuments, the National Geodetic Survey has decided to redefine and readjust the network to produce the North American Datum 1983. The latitude and longitude of almost all points in the United States will change slightly to reflect the correct position in relation to the entire world. A similar readjustment is planned for the vertical network and will be completed by the end of the decade.

Geodetic Survey Control Lists are published by two agencies, the U.S. Geological Survey and the National Geodetic Survey. The National Geodetic Survey horizontal and vertical control data are published separately by 30-minute quadrangles. The price is determined by the number of sheets per booklet. These products may be ordered from: The Director, National Geodetic Survey, NGS Information Center C185, Rockville, Maryland 20852.

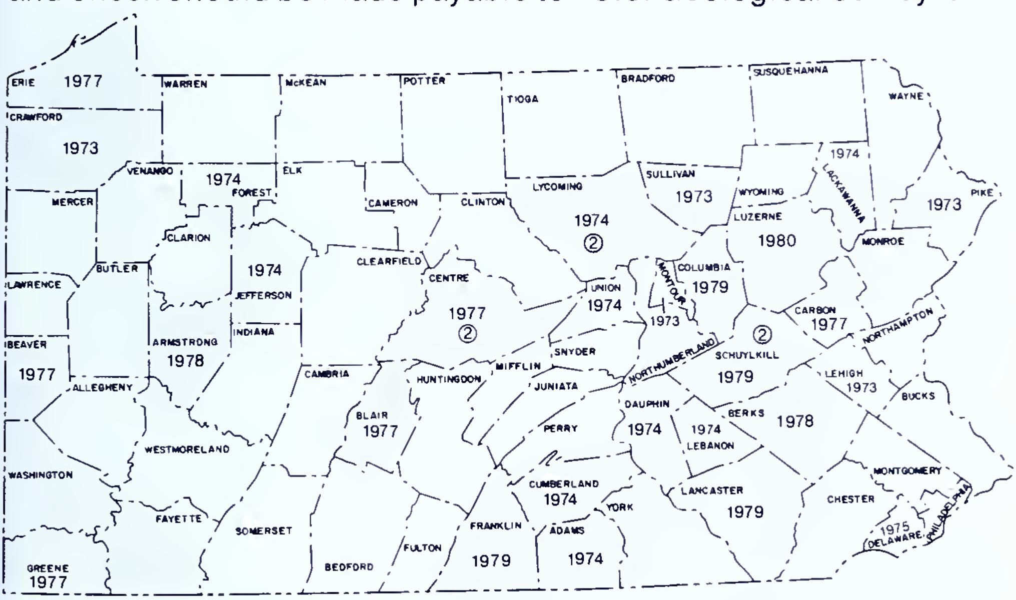
U.S.G.S. vertical control lists contain the descriptions, location, and elevation of bench marks. The horizontal control lists contain the description, geodetic and/or geographic position of transit traverse, triangulation, and electronic traverse stations. Both types of lists are assembled in 15-minute quadrangle units. To order, the area must be identified and the type of list desired. Orders may be placed directly with: Eastern Mapping Center-NCIC, U.S. Geological Survey, 536 National Center, Reston, Virginia 22092.

The Pennsylvania Geological Survey maintains a collection of the U.S. Geological Survey geodetic control lists for public use in its Library in Room 916 of the Executive House, Second and Chestnut Sts., Harrisburg.

Detailed information on this subject may be found in a pamphlet entitled "Measuring the Nation" available from the National Cartographic Information Center at the address listed above.

COUNTY TOPOGRAPHIC MAPS

During the past year new county topographic maps have been published by the U.S. Geologic Survey. The maps are at a scale of 1:50,000 (approximately 400 feet to the inch). These maps are multicolored, following the standard colors of topographic maps, with the addition of political boundaries for county, township and boroughs outlined in orange. These county maps are of widespread use to all who are concerned with county and regional planning, engineering, agriculture, and recreational projects. These maps may be obtained for $3.25 each ($6.50 for Centre, Lycoming, and Schuylkill) by writing to Distribution Section, U.S. Geological Survey, 1200 S. Eads Street, Arlington, Virginia 22202. Prepayment is required and check should be made payable to "U.S. Geological Survey".



The Lehigh County map (map #39) costs $1.00 and is available by writing to the State Book Store, P.O. Box 1365, Harrisburg, Pennsylvania 17125 (Prepayment is required, Pennsylvania residents should add 6% sales tax, and make check payable to the "Commonwealth of Pennsylvania").

GEOLOGICAL RESEARCH IN PENNSYLVANIA 1982

INTRODUCTION

With this issue of "Pennsylvania Geology", you celebrate with us a 25th anniversary. Twenty-seven years ago we began reporting to you on the geological research activity in Pennsylvania. The first report was issued in May, 1956 as "Newsletter No. 1" and contained information on 80 separate projects. Reports were issued in all subsequent years except in 1961 and in 1972, the year of the Hurricane Agnes Flood which destroyed the Bureau offices.

In this, our silver anniversary report on geologic research, we list 89 projects. As the number of reports on research activities has grown greatly over the past quarter century plus, we have had to exercise editorial prerogative in reducing or omitting the description of some activities that were clearly not research in the classic sense of geological work that would be published, or otherwise distributed to fellow workers through normal scholarly methods. The three most active research areas over the past year were Economic Geology, Hydrology and Paleontology. When we started, the three most popular research areas were Stratigraphy, Sedimentary Petrology and Areal Geology. Mineralogy and Igneous and Metamorphic Petrology were least favored in 1956 as in 1982. That's hard rocks for you — consistently hard!

If you wish more information on a project described herein, Most of these projects will not be published by the Pennsylvania Geological survey inasmuch as most are not survey sponsored projects.

The ACD is the anticipated completion date, which is when the author expects to complete his or her project; additional time may elapse before the report is published or distributed.

Happy twenty-fifth anniversary reading to you!

1956	1957	1958	1959	1960
1962	1963	1964	1965	1966
1967	1968	1969	1970	1971
1973	1974	1975	1976	1977
1978	1979	1980	1981	1982

T. M. BERG and W. D. SEVON, Pa. Geol. Survey, and ROBIN ABEL, The Pa. State Univ. Lithologic Map of Pennsylvania. This 1:500,000 map will show 18 rock units. It is a derivative map from the 1980 State Geologic Map. ACD: Late 1982.

W. R. BRICE, BRENDA HOCKENSMITH, and THOMAS MOUREY, Univ. of Pitt. at Johnstown. Loyalhanna Limestone Outcrops—Laurel Ridge, Johnstown, Pa. [Laurel Ridge, NE of Conemaugh Gap]. Loyalhanna Limestone has been found 3 km from mapped positions. The outcrops appear to be erosional windows cut through the Mauch Chunk. ACD: Aug. 1982.

J. D. INNERS, Pa. Geol. Survey. Geology and Mineral Resources of the Allenwood and Milton Quads., Union and Northumberland Cos., Pa. ACD: 1983.

P. T. LYTTLE, Project Chief, U.S. Geol. Survey. Newark 2° Quad. Reconnaissance mapping of the Piedmont portion of the quadrangle, including the Piedmont-Triassic border, will be completed in FY 1982. Areas to be mapped during FY 1982 are located on the north side of Chester Valley and between Phoenixville and Bridgeport in Pa. ACD: Sept. 1984.

S. T. PEES, Samuel T. Pees & Associates, J. C. PALMQUIST, Lawrence Univ., and J. P. VALDES, Samuel T. Pees & Associates. Application of Remote Sensing to the Geology of Northwest Pa. An illustrated lecture (35 mm slides) showing lineaments and other features detected on specially prepared landsat images, return beam vidicon, synthetic aperture radar, VHA U-2 infrared photos and conventional flight photos. ACD: Apr. 1982.

H. A. POHN, T. L. PURDY, A. R. TAYLOR, U.S. Geol. Survey, G. W. COLTON, Ala. Geol. Survey, and G. H. CROWL, Ohio Wesleyan Univ. Geologic Map of the Jersey Shore Quad., Lycoming and Clinton Cos., Pa. The bedrock geologic map has been submitted for review to the U.S. Geol. Survey. The surficial geologic map is completed. ACD: Sept. 1982.

W. D. SEVON and T. M. BERG, Pa. Geol. Survey, L. D. SCHULTZ, Weston Geophysical Corp., and G. H. CROWL, Ohio Wesleyan Univ. Geology and Mineral Resources of Pike Co., Pa. ACD: Fall, 1982.

J. H. WAY, Pa. Geol. Survey. Geology and Mineral Resources of the Washingtonville and Millville Quads., Columbia, Montour, and Northumberland Cos., Pa. Geologic mapping of bedrock and surficial deposits, sampling materials with possible economic potential, and describing environmental and engineering characteristics of all geologic units within the area. ACD: 1982.

1956 1957 1958 1959 1960
1962 1963 1964 1965 1966
1967 1968 1969 1970 1971
1973 1974 1975 1976 1977
1978 1979 1980 1981

K. D. ABEL, C. D. LAUGHREY, and J. A. HARPER, Pa. Geol. Survey. Oil and Gas Geology of Southwestern Pa.

S. W. BERKHEISER, JR., Pa. Geol. Survey. Reconnaissance Study of High-Purity Silica Deposits in Pa. A reconnaissance study of sedimentary, metamorphic, and igneous sources of high-purity (+97%) silica has been initiated to characterize their chemical and physical properties.

S. W. BERKHEISER, JR., Pa. Geol. Survey. Reconnaissance Survey of Bedded(?) Barite Showings in Western Berks Co., Pa. [Frystown area]. This reconnaissance study will attempt to identify the mineral resource potential of apparent bedded barite showings occurring in allochthonous Ordovician Martinsburg (Hamburg Sequence) rocks. Emphasis is placed on mapping lithologic associations and reconnaissance geochemistry. ACD: July 1982.

S. W. BERKHEISER, JR., Pa. Geol. Survey. Reconnaissance Survey of Potential Carbonate "Whiting" Sources in Pa. [SE Pa.]. Nineteen samples from fourteen sources ranging in age from Precambrian to Triassic, were analyzed for brightness, whiteness, and chemical characteristics. Potential economic resources have been identified in three formations of southeastern Pa. ACD: 1982.

C. B. CECIL, R. W. STANTON, F. T. DULONG, L. F. RUPPERT, S. NEUZIL, and T. MOORE, U.S. Geol. Survey. Geology of Contaminants in Coal (USGS/EPA Interagency Agreement) [western Pa.]. This is a study of geologic factors that control coal quality in the Upper Freeport coal bed. Phase I (completed) was a detailed investigation of the Upper Freeport coal reserves near Homer City, PA. Phase II (in progress) assesses the relationship between coal quality and washability in coal preparation. Phase III is a regional investigation of coal quality variation in the Upper Freeport of western Pa. ACD: Dec. 1984.

A. D. GLOVER, C. H. DODGE, J. R. SHAULIS, and V. W. SKEMA, Pa. Geol. Survey. Coal Resources of Western Pa. Data for coal-bearing

strata in Greene, Washington, and Allegheny Counties have been entered into the National Coal Resources Data System (NCRDS) computer. Information for Fayette, Westmoreland, Butler, and Cambria Counties is currently being assembled and prepared for entry into the system. This will result in computer-generated geologic and resource maps for western Pa.

E. M. HOPKINS, Univ. of Pitt. at Bradford. Correlation of Photo-Lineaments (Landsat) with Oil and Gas Production in North-Central and Western Pa. Lineaments coincide with many oil-producing trends in Pa. Those parallel to fold axes indicate brittle deformation during folding. Others trending at high angles to fold axes delineate various types of transverse faults. Exploration rationale will be investigated. ACD: Oct. 1982.

C. D. LAUGHREY, Pa. Geol. Survey. Reservoir Geology of the Athens and Geneva Gas Fields, Crawford Co., Pa. This study consists of four parts: (1) mapping the external form and trend of the reservoirs; (2) petrographic determination of composition and texture; (3) diagenetic history of the reservoir rocks and its relation to porosity and permeability; and (4) reservoir engineering parameters. ACD: June 1982.

S. T. PEES, Samuel T. Pees & Associates, and J. C. PALMQUIST, Lawrence Univ. and Samuel T. Pees & Associates. Petroleum Geology of the Medina Group in a 350 Sq. Mi. Model Area in Crawford and Mercer Cos., Pa. Illustrated text plus 14 maps, scale 1:62,500. Structure, isopachs, sand bar build-ups, channels, remote sensed data, IPF contours, cross sections, correlation diagram, fields, pools, prospective areas, pipelines, detailed geology and reservoir data. ACD: April 1982.

A. T. SMITH and A. W. ROSE, The Pa. State Univ. Geologic and Geochemical Controls on the Formation of Cu-U Red-Bed Occurrences in the Upper Devonian Catskill Formation of Pa. Regional and local stratigraphic controls have been examined. Geochemical constraints determined by fluid inclusion, isotope (C-O) and fluid flow due to compaction have been proposed. An early diagenetic model is being developed. ACD: Oct. 1982.

R. C. SMITH, II, and J. H. BARNES, Pa. Geol. Survey. Geologic and Mineralogic Interpretation of Gamma-Ray Reconnaissance Data for the Reading Prong, Easton, Pa. [portions of Berks, Bucks, Lehigh, and Northampton Cos.]. The composition and mineralogy of 60 host rocks have been determined. Gamma-ray spectrometer and magnetometer data have been obtained at the more interesting areas of uranium mineralization. ACD: 1983.

R. C. SMITH, II, Pa. Geol. Survey, and D. T. HOFF, Wm. Penn Memorial Museum. Copper-Uranium Occurrences in the Catskill Formation, Picture Rocks and Sonestown Quads., Pa. Geologic and mineralogic studies of 50 small Cu-U bearing lenses have been completed. Quantitative analyses for U, Cu, As, and Pb as well as semiquantitative data for several others have been interpreted. Mineralogic data for some rare minerals are included. ACD: 1982.

R. W. STINGELIN, Resource Technologies Corp. Defining the Anthracite Resources of Northeastern Pa. (U.S. Dept. of Energy Contract #DE-AC01-80ET 14375). Remaining coal resource estimates are established for the Northern, Western Middle, Eastern Middle, and Southern Anthracite fields. Recoverable resources (reserves) are also estimated using conventional surface mining, underground mining, and deep open pit mining techniques. An atlas of minability using reduced U.S.G.S. quadrangle maps is included in the report. ACD: Aug. 1982.

ENGINEERING GEOLOGY

1956	1957	1958	1959	1960
1962	1963	1964	1965	1966
1967	1968	1969	1970	1971
1973	1974	1975	1976	1977
1978	1979	1980	1981	1982

W. B. FERGUSSON, Villanova Univ., ALBERT DEPMAN, Consultant, and EDWARD DOHENY, Drexel Univ. Engineering and Environmental Geology of Philadelphia, Pa. ACD: Summer 1982.

J. V. HAMEL, Hamel Geotechnical Consultants, and H. M. FAUSOLD and C. E. STEVENSON, U.S. Army Corps of Engineers, Pbg. District. Bank Instability on the Monongahela River, Pa. [six sites along Monongahela River, 92 to 103 km]. Bank instability is being investigated at six sites along the Monongahela River 92 to 103 km upstream from Pbg. ACD: June 1983.

ENVIRONMENTAL GEOLOGY

1956	1957	1958	1959	1960
1962	1963	1964	1965	1966
1967	1968	1969	1970	1971
1973	1974	1975	1976	1977
1978	1979	1980	1981	1982

T. W. GARDNER and R. L. SLINGERLAND, The Pa. State Univ., and DONALD STUMP, U.S. Geol. Survey. Morphologic Changes of Streams with Strip-Mined Basins [Big Sandy Creek, Fayette Co.]. Baseline survey of channel hydraulic geometry has been completed. Water quality and hydrologic data are presently being taken to define the pre-mining condition. ACD: 1985.

T. W. GARDNER and K. C. N. TOUYSINHTHIPHONEXAY, The Pa. State Univ. The effect of Strip Mining on Stream Morphology. ACD: May 1982.

J. P. WILSHUSEN and H. L. DELANO, Pa. Geol. Survey. Landslide Risk Assessment, Williamsport 1° x 2° Map [north-central Pa.]. A regional landslide risk assessment map classifying landslides and landslide potential with correlation to geology, slope, and soils. Will include a text with reduced 7½-minute maps. ACD: June 30, 1983.

1956 1957 1958 1959 1960
1962 1963 1964 1965 1966
1967 1968 1969 1970 1971
1973 1974 1975 1976 1977
1978 1979 1980 1981

J. P. FAWLEY, Westminster Coll. Mapping of Harlansburg Cave. Mapping the longest cave in Pa. ACD: May 1982.

L. B. PLATT and HERMINIO MUNIZ, Bryn Mawr Coll. Geology of Little Mountain and Surrounding Area, North of Fredricksburg, Pa. Mapping shows Upper Ordovician and/or Silurian resting on shales of the Great Valley. Work is in progress to determine the nature of the contacts. ACD: May 1982.

R. E. SHERIDAN, Univ. of Del. Comparison of Iapetus Passive Margin with Modern Atlantic Analogs [SE Pa., York and Lancaster Cos.]. Field relationships between the Cambro-Ordovician carbonate bank, carbonate fans, and ophiolitic sequences suggest an excellent comparison to modern Atlantic margins. ACD: 1984.

C. A. SHUMAN and JOSEPH GERENCHER, JR., Moravian Coll. A Multi-Variate Statistical Analysis of Selected Physical and Chemical Variables from Coals Sampled Over a Five County Region of Western Pa. [Cambria, Indiana, Armstrong, Butler, and Lawrence Cos.]. ACD: May 15, 1982.

J. P. WILSHUSEN, Pa. Geol. Survey. Geology of the Appalachian Trail in Pa. [SE Pa.]. A description of geologic characteristics of each physiographic province crossed by the trail with detailed, illustrated geologic accounts at points of interest along the route. Sketch maps, geologic cross sections, and descriptions are keyed to a geologic map of the trail. ACD: Nov. 1982.

GEOMORPHOLOGY

1956 1957 1958 1959 1960
1962 1963 1964 1965 1966
1967 1968 1969 1970 1971
1973 1974 1975 1976 1977
1978 1979 1980 1981 1982

T. W. GARDNER, The Pa. State Univ. Evolution and Erosion of Pleistocene Alluvial Fans in Central Pa. ACD: 1983.

KEN LAURIE, Univ. of Ill. at Urbana. Geomorphic Analysis of Paraglaciation on the Wisconsinan Glacial Border in North-Central Pa. [Elk Grove and Red Rock quads.]. Sedimentologic data attest to a period of widespread and rapid mass wasting during the close of the last episode of glaciation. Corresponds to paraglacial deposits reported by Church and Ryder (1972) in British Columbia and Baffin Island. ACD: Sept. 1982.

NOEL POTTER, JR., Dickinson Coll. Distribution and Origin of Gravels and Colluvium in Cumberland and Franklin Cos. Continuation of mapping of thick gravels along the flanks of South and Blue Mountains, and their relations to residuum weathered from underlying carbonates and to alluvial terraces along Conodoguinet, Yellow Breeches, and Conococheague Creeks. ACD: Continuing.

G. H. THOMPSON, JR., Elizabethtown Coll. Incised River Meander Cutoffs in the Central Appalachian Region. Cutoffs attributed to intensified lateral stream activity during Pleistocene periglacial climate regimes.

E. L. WHITE and W. B. WHITE, The Pa. State Univ. Quantitative Geomorphology of the Appalachian Karst. A systematic description and measurement of surface and underground karst landforms from Pa. to Ala. and their interpretation in terms of dissolution chemistry and Pleistocene climates. ACD: 1990?

W. B. WHITE, The Pa. State Univ. Survey of Pa. Caves. The object is to compile a complete set of descriptions and maps of all caves known in Pa. ACD: 1984.

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1962 1963 1964 1965 1966
1967 1968 1969 1970 1971
1973 1974 1975 1976 1977
1978 1979 1980 1981 1982

GEOPHYSICS

D. D. BRAUN, Bloomsburg State Coll., and J. D. INNERS, Pa. Geol. Survey. Geophysical Investigations of the Ten Mile Run Valley and Orangeville "Umlaufberg," Columbia Co., Pa.

W. H. DIMENT, Project Chief, U.S. Geol. Survey. Seismotectonics of Northeastern U.S. Existing geological and geophysical information that is relevant to the problem of earthquake distribution and cause in the northeastern U.S. will be integrated during FY 1982. A terrain corrected Bouguer gravity anomaly map of Pa. will be completed. ACD: Sept. 1983.

L. J. LaFOUNTAIN, D'Appolonia Geophysical Corp. Various Geophysical Surveys for Oil and Gas [Fayette, Somerset, and Westmoreland Cos.]. High-resolution and conventional surveys to explore for oil- and gas-bearing structures in western Pa. ACD: Ongoing.

F. E. SENFTLE, Project Chief, U.S. Geol. Survey. Magnetic Properties of Coal. Using samples from Pa., Ky., R.I., Ill., and Ohio, the study of change in the magnetic properties of pyrite as a function of temperature and oxidizing atmosphere will continue in FY 1982. Some measurements are also planned for illite in coal. The basic studies of chemical oxidation of anthracite will be continued in terms of charge transfer, pH, and chemical environment. A field study of the electrolytic oxidation of coal is tentatively planned in Pa., with the idea of solution mining of coal, if time and funding permit. ACD: Sept. 1982.

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1962 1963 1964 1965 1966
1967 1968 1969 1970 1971
1973 1974 1975 1976 1977
1978 1979 1980 1981 1982

GLACIAL GEOLOGY

D. D. BRAUN, Bloomsburg State Coll. Wisconsinan Deglaciation Sequence of North Central Pa. Reconnaissance mapping of the distribution of surficial deposits, with detailed mapping of selected

areas to determine ice recessional positions between the terminal moraine and the New York State line. ACD: Continuing.

JAMES COTTER and E. B. EVENSON, Lehigh Univ., LES SIRKIN, Adelphi Univ., BOB STUCKENRATH, Smithsonian Inst., and W. D. SEVON, Pa. Geol. Survey. Deglaciation Chronology of NE Pa. and NW N.J. This project has attempted to determine the timing of the Late Wisconsinan (Woodfordian) deglaciation. A radiocarbon date of 18,570 from the base of a post-glacially formed lake has been obtained. Other dates and palynologic evidence suggest this date may accurately represent the age of deglaciation. ACD: June 1983.

J. C. RIDGE, Lehigh Univ., CARL KOTEFF, U.S. Geol. Survey, W. D. SEVON, Pa. Geol. Survey, and E. B. EVENSON, Lehigh Univ. The Surficial Geology of the Great Valley in Northampton Co., Pa., and Warren Co., N.J. Mapping according to the sequence concept has resulted in the recognition of numerous ice-marginal positions and episodes of substantial stillstands during the Woodfordian deglaciation. ACD: Dec. 1982.

HYDROLOGY

1956 1957 1958 1959 1960
1962 1963 1964 1965 1966
1967 1968 1969 1970 1971
1973 1974 1975 1976 1977
1978 1979 1980 1981 1982

W. J. HERB and D. E. BROWN, U.S. Geol. Survey. Research Modeling in Coal Areas [Clearfield and Westmoreland Cos.]. A U.S. Geol. Survey precipitation-runoff model will be calibrated for two basins in coal areas. The model's utility in predicting hydrologic consequences of mining will ultimately be tested. Sites are presently being instrumented. ACD: Sept. 1984.

J. R. HOLLOWELL and P. B. BALLARON, Susquehanna River Basin Comm. Special Ground-Water Study of the Susquehanna River Basin. Final report by the Commission staff and summary of the findings and conclusions from 13 ground-water research projects. The projects, partially funded by the Water Resources Council, were conducted in Pa., N.Y., and Md. by participating water resource agencies. ACD: Dec. 1982.

THOMAS McELROY, Pa. Geol. Survey. The Groundwater Resources of Fayette Co., Pa. The project will provide a description and in-

ventory of groundwater resources in Fayette County. Particular emphasis is being put on the impact of coal mining on groundwater quality. Field work is completed. ACD: June 1982.

G. N. PAULACHOK, U.S. Geol. Survey. Hydrologic Investigations of the Ground-Water Resources in the Commonwealth of Pa. Objectives are to determine the quantity, quality, and availability of ground water in areas where needed information is not available or where major changes in the hydrologic system have occurred since the last study. Project will begin in Delaware County. ACD: Sept. 1984.

G. N. PAULACHOK, U.S. Geol. Survey. Water Resources of the Oley Valley, Berks Co., Pa. Objectives are to evaluate the water resources of the Oley Valley to provide basic hydrologic data on which future management decisions may be based. Stream gaging stations, observation wells, and rain gage network has been established. Water table map is in preparation. ACD: Mar. 1983.

D. W. ROYER, Pa. Geol. Survey. Summary Groundwater Resources of Lebanon Co. ACD: June 1982.

R. A. SLOTO, U.S. Geol. Survey. Impact of Urbanization on the Quality and Quantity of Ground and Surface Water in Eastern Chester Co., Pa. ACD: Sept. 1985.

L. E. TAYLOR, Pa. Geol. Survey, and WILLIAM WERKHEISER and M. L. KRIZ, Susquehanna River Basin Comm. Groundwater Resources of the Central and Upper Susquehanna River Basin, Pa. ACD: Oct. 1982.

L. E. TAYLOR, Pa. Geol. Survey, and WILLIAM WERKHEISER and M. L. KRIZ, Susquehanna River Basin Comm. Groundwater Resources of the Lower Susquehanna River Basin, Pa. ACD: Sept. 1982.

L. E. TAYLOR, Pa. Geol. Survey, and WILLIAM WERKHEISER and M. L. KRIZ, Susquehanna River Basin Comm. Groundwater Resources of the West Branch and Western Part of the Upper Susquehanna River Basin, Pa. ACD: Aug. 1982.

D. W. WILLIAMS, J. D. STONER, and others, U.S. Geol. Survey, and C. H. DODGE, Pa. Geol. Survey. The Effect of Coal Development on the Water Resources of Greene Co., Pa. Most data collection is complete with the exception of selected streamflow quantity and quality measurements and ground-water level observations. Data analysis and preliminary ground-water modeling indicate that hydrologic effects of mining may be local in extent. ACD: Sept. 1982.

C. R. WOOD, G. N. PAULACHOK, and R. A. SLOTO, U.S. Geol. Survey. Appraisal of the Ground-Water Resources of the Philadelphia Area, Pa. Objectives are to evaluate the quantity and quality of water available in aquifers underlying Philadelphia and to develop a predictive two-dimensional digital computer model of ground-water flow. Water-table map and basic data report have been completed. ACD: Sept. 1982.

1956	1957	1958	1959	1960
1962	1963	1964	1965	1966
1967	1968	1969	1970	1971
1973	1974	1975	1976	1977
1978	1979	1980	1981	1982

F. H. ROBERTS, LAWRENCE MARK, and PAUL FARREL, Delaware County Christian Sch. Structural Geology and Petrology of High Grade Metamorphic Rocks between Lima and Marcus Hook, Pa. Objective is to investigate the mapped boundary between the Wissahickon Formation and the Precambrian rocks. The relationship between charnockitic and noritic rocks and apparently similar rocks northeast of Lenni is being studied. ACD: 1985?

1956	1957	1958	1959	1960
1962	1963	1964	1965	1966
1967	1968	1969	1970	1971
1973	1974	1975	1976	1977
1978	1979	1980	1981	1982

W. B. WHITE, The Pa. State Univ. Mineralogy of Caves. Description, trace element geochemistry, and depositional mechanism of secondary minerals from limestone caves.

1956	1957	1958	1959	1960
1962	1963	1964	1965	1966
1967	1968	1969	1970	1971
1973	1974	1975	1976	1977
1978	1979	1980	1981	1982

P. S. BOYER, Fairleigh Dickinson Univ. Scolecodonts from the Devonian Oriskany Group, Monroe Co., Pa. Scolecodonts from the Oriskany Group have been isolated from acid residues. Descriptions will compare these with other Devonian scolecodonts from Ohio, Ky., and Mich. ACD: Summer 1983.

E. B. EVENSON, Lehigh Univ., JOHN GUILDAY, Carnegie Inst., BOB STUCKENRATH, Smithsonian Inst., and JIM COTTER, KATHY VANDERWAL, DAVE CUNDALL, and JOHN GATEWOOD, Lehigh Univ. The Paleo-Ecology of a Pleistocene Sinkhole, Hanover, PA. Radiocarbon dates, faunal assemblages, and pollen analysis have been utilized to determine the age and history of a post-Illinoian sinkhole. Radiocarbon ages of 41,800 and 37,800 years B.P. serve as minimum dates for this deposit. ACD: Dec. 1982.

J. A. HARPER, Pa. Geol. Survey. Fossils of the Pittsburgh Area—A Guide to Collecting in the Tri-State Region. A general fossil hunting guide to southwestern Pa. with limited references to Ohio, W.Va., and Md. Will list localities and known fossil species that can be found. ACD: Dec. 1982.

D. M. HOSKINS, J. D. INNERS, and J. A. HARPER, Pa. Geol. Survey. Fossil Collecting in Pa. Complete revision of General Geology Report 40. ACD: 1982.

W. F. KLOSE, II, Paleontological Research Inst. Contributions to the Pennsylvanian Age Flora and Fauna of the Anthracite and Semi-Anthracite Coal Fields of NE Pa. Collection of Pennsylvanian age flora and fauna with deposition of prepared specimens in the William Penn Memorial Museum, Harrisburg. ACD: Ongoing.

W. F. KLOSE, II, Paleontological Research Inst. Fossil Flora and Fauna of the Ross Anthracite at the Larksville Mine Fire Excavation, Luzerne Co. ACD: July 1, 1984.

W. F. KOCH, II, Waynesburg Coll. Biostratigraphy, Brachiopod Community Paleoecology, and Depositional Topography of the Upper Middle Devonian Hamilton Group in the Appalacian Basin [NY, PA, MD, VA, WV, OH, Ontario, TN, KY]. ACD: 1983-84.

G. R. McGHEE, JR., Rutgers Univ., and R. G. SUTTON, Univ. of Rochester. Late Devonian Marine Ecology and Zoogeography [along the Allegheny Front across the entire state, and in NW Pa.]. The project concerns the marine ecology and zoogeographical distribution patterns of marine animals which existed during the Late Devonian, and the response of those animals to the collapse of the ecosystem which occurred during the end of the Frasnian Epoch. ACD: Open ended.

W. A. OLIVER, Project Chief, U.S. Geol. Survey. Upper Silurian/Lower Devonian Biostratigraphic Framework of the Central Appalachians. Fieldwork in Pa., N.J., and SE N.Y. will be underway in FY 1982 in order to supplement earlier collections. A report on Manlius-Coeymans ostracodes identified during this fieldwork will be prepared. Analysis and description of stromatoporoid-facies corals is also planned. A report on the ecological aspects of Devonian corals of N.Y. will be in preparation. Analysis of worldwide Devonian rugose corals will be completed, and a report documenting the results of this study will be prepared. ACD: Sept. 1985.

W. A. OLIVER, JR., and J. M. BERDAN, U.S. Geol. Survey. Uppermost Silurian-Lower Devonian Coral/Ostracode Biostratigraphy in the Central Appalachians [Appalachians from N.Y. to Va.]. Pennsylvania part of project is a study of the systematics and distribution (stratigraphic and geographic) of corals and ostracodes in the Keyser, Decker, and Helderberg Limestones. ACD: 1984.

ALFRED TRAVERSE and N. G. JOHNSON, The Pa. State Univ., and P. K. STROTHER, Harvard Univ. Palynological-Paleobotanical Study of Primitive Land Plants in the Tuscarora Formation and Other Lower Silurian Rocks of Pa. [central and eastern Pa.]. Investigation of mostly microscopic, but some megascopic, plant remains in the lower Silurian rocks of Pa. is a continuing project of our laboratory. Studying remains of these pre-vascular embryophytic plants is important to understanding the early evolution of the land flora. ACD: Continuing.

E. L. YOCHELSON, U.S. Geol. Survey, and J. D. INNERS and J. H. WAY, Pa. Geol. Survey. Styliolines in the Middle Devonian of Pa. The small pelagic styliolines may be useful for correlation. Anyone having specimens is asked to submit them to Yochelson for identification. Are there any early Upper Devonian occurrences in the state? ACD: 1983.

1956 1957 1958 1959 1960
1962 1963 1964 1965 1966
1967 1968 1969 1970 1971
1973 1974 1975 1976 1977
1978 1979 1980 1981 1982

SEDIMENTOLOGY

EDWARD COTTER, Bucknell Univ. Sedimentology of the Tuscarora Formation [central Pa.]. ACD: Summer 1982.

A. L. GUBER and TED SHUSTER, The Pa. State Univ. Facies Analysis of the Rose Hill and Mifflintown Formations [central and western Pa.]. A geochemical, paleontological, and sedimentological approach is being used to define facies sequences, prepare facies maps, and develop facies models for the Mifflintown and Rose Hill Formations. ACD: 1984?

S. W. NEWSOM, Univ. of Delaware. A Paleogeographic Model for Middle Ordovician Lithofacies in Central Pa. [Centre, Huntingdon, Blair, and Mifflin Cos.]. Carbonates and shales of Middle Ordovician age are currently being examined, with emphasis on sedimentation processes that document the change from a carbonate to a siliciclastic depositional regime across central Pa. ACD: Dec. 1982.

D. L. WOODROW, Hobart and William Smith Coll., Shoreline Facies of the Catskill Delta in Northern and Central Pa. ACD: 1984.

D. L. WOODROW, Hobart and William Smith Coll. and DAVID DINELEY, Univ. of Bristol, England. Fishing Along the Catskill Shore: Taxonomy and Environments [north-central Pa.]. ACD: 1984.

1956 1957 1958 1959 1960
1962 1963 1964 1965 1966
1967 1968 1969 1970 1971

STRATIGRAPHY

1973 1974 1975 1976 1977
1978 1979 1980 1981 1982

W. R. BRICE and K. M. JONES, Univ. of Pitt. at Johnstown, Mauch Chunk Marine Limestone Correlation—Clark Run—Conemaugh Gap [small stream and roadcut—Route 403 near Cramer, Pa.]. A small marine limestone in the Mauch Chunk crops out along Rte. 403 near Cramer, PA, and in Clark Run. The project will produce a detailed measured section and correlations with other Mauch Chunk sections. ACD: Aug. 1982.

W. R. BRICE, TIMOTHY PERRY, and PATRICK CRAFT, Univ. of Pitt. at Johnstown. Allegheny Group Measured Section—Rte. 56, Johnstown, PA. [Rte. 56 bypass]. Roadcuts on Rte. 56 in Johnstown, PA have exposed a good section of the Allegheny Group. The project will produce three or four measured sections and correlations with other Allegheny sections. ACD: Dec. 1982.

A. D. GLOVER, C. H. DODGE, J. R. SHAULIS, and V. W. SKEMA, Pa. Geol. Survey. TASIC (Temporarily Available Stratigraphic Informa-

tion Collection). A continuing program for recording stratigraphic data on active coal and clay strip mines while exposures are available. The ongoing project is designed to provide data for future mapping and regional mineral resource evaluation.

R. W. GOODWIN and E. J. ANDERSON, Temple Univ. Punctuated Aggradational Cycles in Limestones of the Helderberg Group, Appalachian Basin. A sedimentologic and stratigraphic analysis of the Helderberg Group applying the hypothesis of Punctuated Aggradational Cycles (PACs). The ultimate goal is to correlate small-scale time-stratigraphic rock units (PACs) throughout the Helderberg Basin and interpret the paleogeography represented by each PAC.

M. K. McINERNEY, W.Va. Univ., and T. M. BERG, D. B. MacLACHLAN, and J. H. WAY, Pa. Geol. Survey. Stratigraphic Correlation Diagram for Pa. The correlation chart has been reviewed by about 35 geologists outside the Pa. Survey, and has also been reviewed internally. Final revisions are being made, and the diagram will be published as a General Geology Report. ACD: Late 1982.

S. T. PEES, Samuel T. Pees & Associates. Cambrian Hydrocarbon Prospects, Stratigraphy and Basement Tectonics, NW Pa. Structural map on top of crystalline basement and portrayal of anomalous features in the Cambrian column. Crawford, Mercer, and Venango Counties comprise the main region of interest. ACD: Dec. 1982.

STRUCTURAL GEOLOGY

1956 1957 1958 1959 1960
1962 1963 1964 1965 1966
1967 1968 1969 1970 1971
1973 1974 1975 1976 1977
1978 1979 1980 1981 982

ERIC ERSLEV, Lafayette Coll. Element Distribution and Morphology of Solution Cleavage in the Bossardville Limestone, Pa. [Bossardsville, Pa.]. Solution cleavage in the Bossardville Limestone has been studied using S.E.M. imaging and E.D.S. analysis. Preliminary results indicate that calcite dissolved from the selvages leaving a residue of illite, quartz, and pyrite. ACD: 1983.

RODGER FAILL, Pa. Geol. Survey. Tectonic Map of Pa. Delineation of anticlines, synclines, and faults; portrayal of igneous rocks; basement contours; structure contours on Onondaga limestone in Pla-

teau; delineation of tectonic phases and lithotectonic units; unconformities; major fracture orientations; metamorphic facies; radiometric dates, earthquake epicenters; geothermal gradient; cross sections; text. ACD: Dec. 1982.

P. GEISER, Univ. of Conn., and R. D. DALLMEYER, Univ. of Ga. Collaborative Structural and Geochronologic Investigation of Alleghenian Deformational Events in the Central and Northern Appalachian Foreland [Pocono Plateau, Pa. Valley and Ridge]. ACD: July 1, 1983.

R. P. NICKELSEN, Bucknell Univ. Strain Discontinuities in the Valley and Ridge Province, Pa. Studying regional variation in finite strain of the Bloomsburg Formation using deformed green spots; bed-parallel deformation zones, and ambient temperatures during the Alleghany Orogeny using fluid inclusions in structurally dated veins. ACD: 1983.

S. T. PEES, Samuel T. Pees & Associates, J. C. PALMQUIST, SCOTT CHASE, and others, Lawrence Univ., and ANTONIO SEGOVIA, Univ. of Md. Detailed Fracture Trace Study of Portions of NW Pa. [Crawford, Erie and Mercer Cos. in particular]. Fracture traces are picked from enlarged aerial photographs and depicted on specially prepared base maps, scale 1″ = 1,000′. Fracture traces are normally less than one mile in length. Fractures may advantageously affect some hydrocarbon reservoir beds. ACD: June 1982.

H. A. POHN, Project Chief, U.S. Geol. Survey. Structural Studies of Allegheny Plateau Using Remote Sensing. Mapping along the Appalachian structural front in Pa. has been completed. During FY 1982 mapping of disturbed zones in the Valley and Ridge Province in Pa. will be completed. Disturbed-zone mapping will be extended during FY 1982 to include the Appalachian structural front and the Valley and Ridge in Md. and W. Va. ACD: Sept. 1984.

H. A. POHN and T. L. PURDY, U.S. Geol. Survey. The Structure of the Appalachian Structural Front in Pa. The detailed structure of the 50 quadrangles along the Appalachian structural front has been completed. Comparisons of structural style with styles exhibited on the Appalachian Plateau and Valley and Ridge provinces is being synthesized. ACD: Fall 1982.

S. N. WILLIAMS, Indiana Univ. of Pa. A Geological Study of a Portion of the St. Marys, Pa., 7.5′ Quad. A geological map of the eastern portion of the quadrangle has been completed. Significant structural control of the area has been obtained and some problem areas have been looked at with some very positive results. ACD: Apr. 29, 1982.

REPORTS PUBLISHED

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BARRY LAWSON ASSOCIATES, 1981, Permit requirements for energy and other natural resources for the State of Pennsylvania. U.S. Geol. Survey Open-File Rept. 81-1277, 105 p.

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SURVEY ANNOUNCEMENTS

SWATARA STATE PARK GUIDE

The Pennsylvania Geological Survey has just released the Swatara State Park Guide, another addition to its park guide series. Park Guide 16, written by Denise W. Royer, discusses the general geology of the Swatara Park area as well as the formation of the Swatara Gap. Geologic features are discussed including a prominent disconformity adjacent to the park area and exfoliation weathering in the Mahantango Formation. The guide also describes two excellent fossil collecting sites and includes sketches of the specimens most commonly collected at each location. This park guide is available at the Swatara State Park office and the Pennsylvania Geological Survey's office in Harrisburg.

MINERAL & GEM SHOW

"The Central Pennsylvania Rock & Mineral Club, Inc. will hold its 17th annual Gem, Mineral & Jewelry Show in the Tile Room of the Zembo Temple, 2801 N. Third Street, Harrisburg, Pennsylvania on September 11 and 12. Hours: 11th—10 a.m.-7 p.m.; 12th—10 a.m.-5 p.m.

Exhibits by club members will include mineral specimens, fossils, spheres, jewel trees, cabachons and faceted stones, and jewelry. Club members will give demonstrations of silversmithing and lapidary work. Dealers will have minerals, fossils, gemstones, jewelry, and supplies for sale. Ample free parking."

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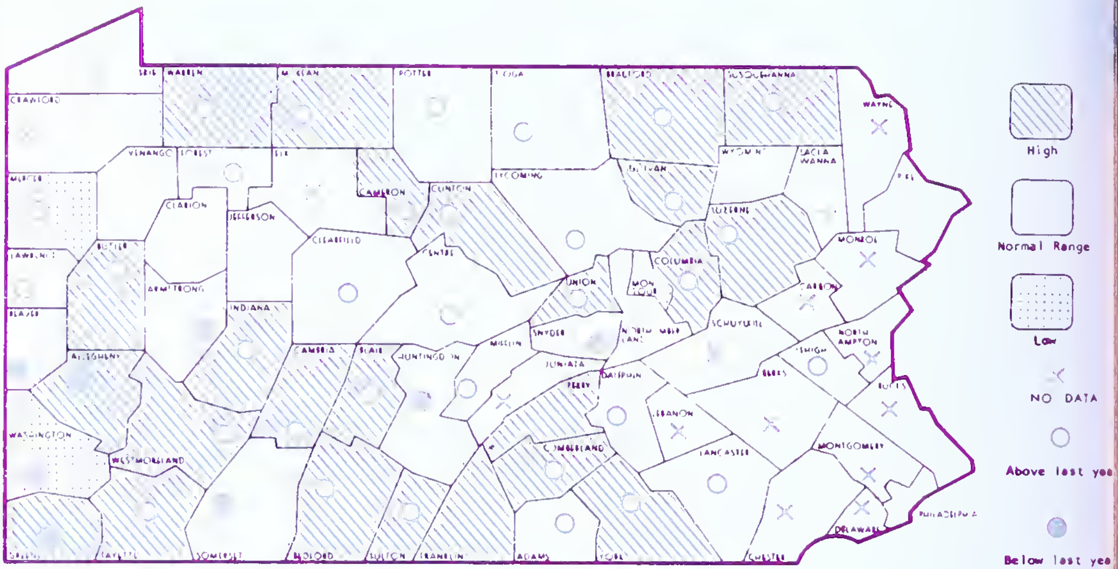

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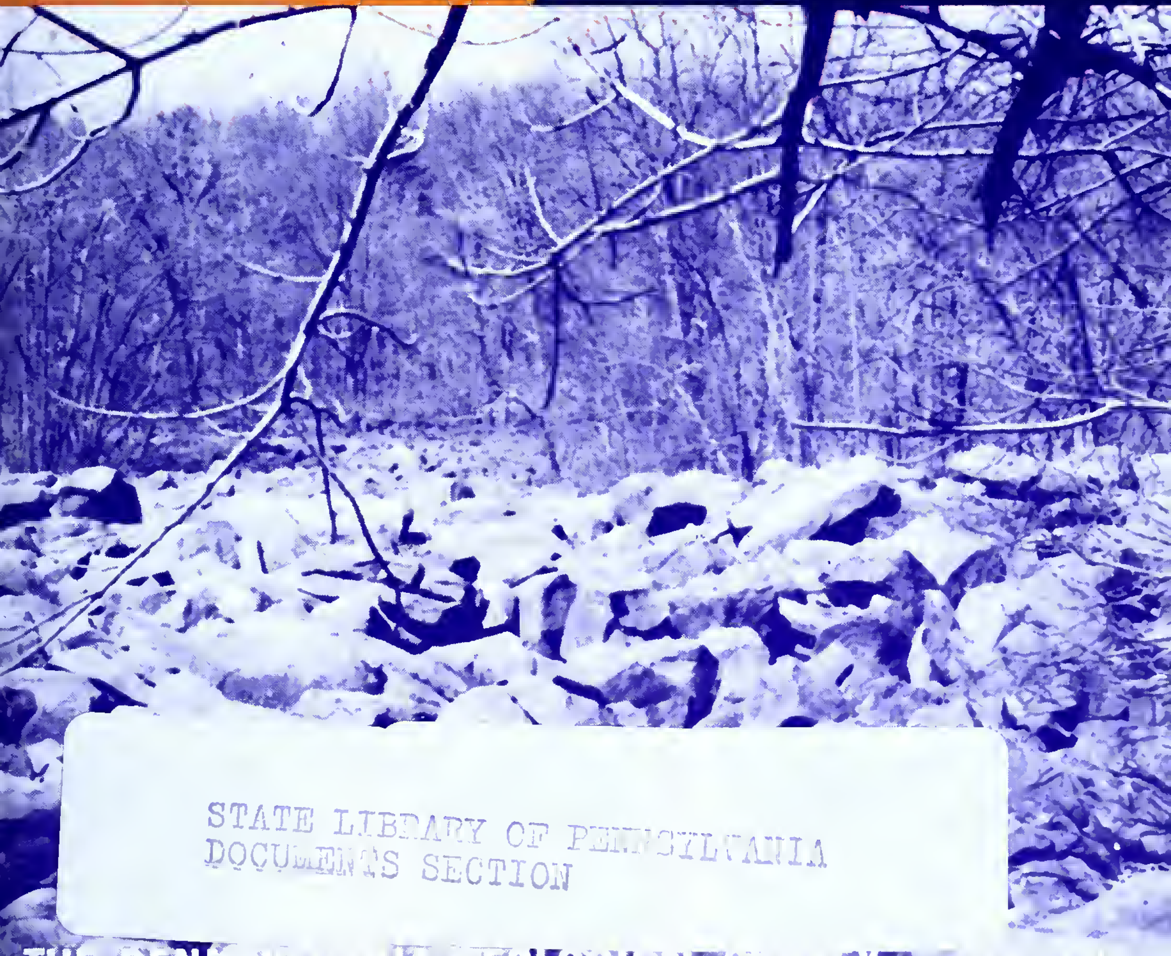

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TOPOGRAPHIC AND GEOLOGICAL SURVEY
Arthur A. Socolow, State Geologist

CONTENTS

ON THE COVER: Ringing Rocks County Park, 1 mile west of Upper Black Eddy, Bucks County. A diabase boulder field (largest in the East) where it is possible to play a tune (Rock of Ages) by striking boulders with a hammer.

PENNSYLVANIA GEOLOGY is published bimonthly by the Topographic and Geologic Survey, Pennsylvania Dept. of Environmental Resources, Harrisburg, Pennsylvania, 17120.

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October 1982

FROM THE DESK

OF THE

STATE GEOLOGIST . . .

SO WHAT'S THE WORTH OF A GEOLOGIC REPORT?

Recently a highly dedicated watchdog of space and dollars suggested we dispose of our stock of published geologic reports because many of them are more than two years old. People who publish are supposed to know that it's all over for a book after a year and a half. I tried to explain that while Pennsylvania has undergone numerous geological upheavals over the millions of years, our geological reports would still be valid and useful after several decades. Our efficiency expert didn't give up. How come, said he, most of the geologic reports we have issued only sell 20 to 50 copies a year — how important can they be?

Good question: How important is a geologic report? How much is the report worth if it enables the highway department to pick a route that saves millions of dollars in construction costs? What's the value if the report identifies the location of mineral deposits needed to provide lime for the farmers, clay for the brickmakers, or coal for the steel industry? To justify its existence, how many copies of a geologic map must be sold which shows the location of geologic faults hazardous to nuclear power plants, and the location of sinkholes hazardous to schools and dams? How do you assess the value of a geologic report which identifies the location of groundwater needed to locate a new glass factory employing hundreds, or a sprawling, new multimillion dollar bottling operation? If our reports lead to natural gas occurrences that heat our homes, and dam sites that keep them from being flooded, must we sell as many copies as *Gone With the Wind* to justify their existence? Among those who tunneled the Turnpike, designed routes 80 and 81, engineered the renewal of Philadelphia, developed water wells for thirsty Lehigh, Bucks, and Chester Counties, rehabilitated the stripped lands of Western Pennsylvania, none of those eager users of our geologic reports were less thankful because the reports were done 10 years ago and the sale of the publications did not make the Times' best seller list.

To those who concern themselves over cost benefit ratios, turnover, and timeliness, we who issue geologic reports say: rest easy. Be assured the value of the report is not measured by its $4.75 price (plus tax); nor does its 1962 date relegate it to the uselessness of a vintage phone book, nor does its annual sale of 47 copies measure real need. Whether they provide mineral raw materials for our industries, locate the waters needed for our survival, identify the geologic hazards that can ruin us, or assist the road-builders, farmers, and recreation planners, our geologic reports measure up well to the test of time and value.

Arthur A. Socolow

The "Eastern Overthrust Belt": An Explanation of Oil and Gas Activities in Central and Eastern Pennsylvania

by John A. Harper and Christopher D. Laughrey
Pa. Geological Survey

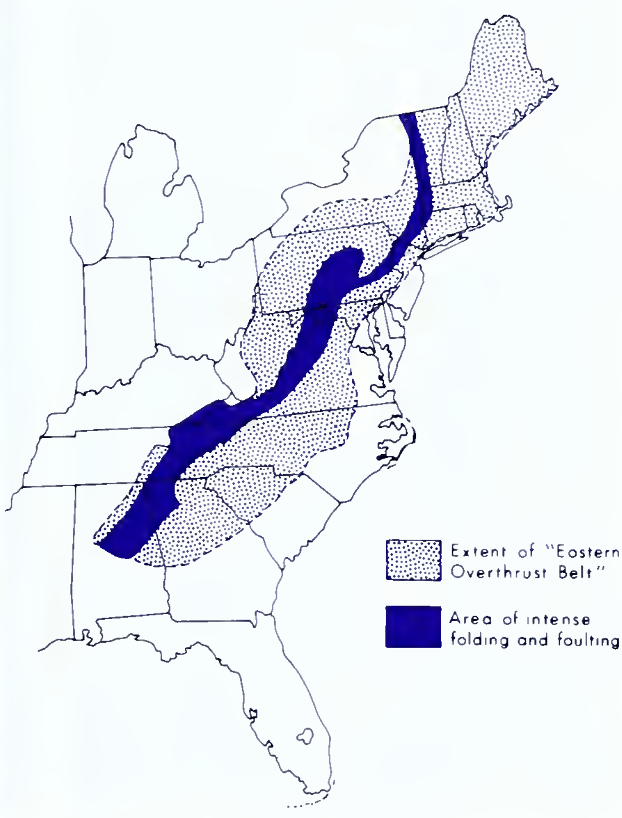
Within the last year or two there has been a flurry of activity in the central and eastern parts of Pennsylvania as large oil companies, seismic surveying crews and land speculators moved into these areas. Industry has invested millions of dollars and hundreds of man-years of work in an area that has traditionally been considered non-productive or uneconomical as far as oil and natural gas are concerned. With so much interest being spurred throughout Pennsylvania, we receive numerous questions from the general public, news media, consumer groups, and companies outside the Appalachian area as to what this activity means. What is the reason for this sudden interest in previously undrilled, unexplored, and unleased land in Pennsylvania, we are asked, and what will it mean to the citizens and industry of the Commonwealth? The interest is not restricted to Pennsylvania; the oil industry has targeted the entire Appalachian Mountain system, from Alabama to New England, for this exploratory and leasing activity, all because of what has become known in recent years as the "Eastern Overthrust Belt". The "Eastern Overthrust Belt", a term basically synonymous with the Appalachian Mountains, consists of a large assortment of folds and normal, strike-slip, and high-angle reverse faults as well as abundant low-angle thrusts of various dimensions.

The areal extent of the "Eastern Overthrust Belt" is a matter of argument. Many geologists, especially those associated with oil companies which search for oil and gas in "exotic" places, consider it restricted to the Valley and Ridge and the Great Valley provinces of the Appalachian chain, those areas associated with intense folding and faulting in Lower and Middle Paleozoic rock. Some investigators suggest that the major overthrusts extend from the Valley and Ridge eastward to the present continental margin, involving the Blue Ridge, Piedmont and Coastal Plain. Others, particularly geolo-

gists with the U.S. Geological Survey, consider the "Eastern Overthrust Belt" to include all these and other areas of the Appalachian Mountain system, including the structurally complex portions of the Allegheny Plateau (Figure 1). The latter view is reflected by the so-called overthrust test wells being drilled in the plateau areas of southeastern New York and northcentral Pennsylvania. Some companies have even leased land and are planning to drill in the greatly deformed crystalline rocks of western Vermont. Under the circumstances, Pennsylvania citizens should not be too surprised by offers to lease their land.

The "Eastern Overthrust Belt" concept is, generally speaking, not new. It has as its basis what is known as "thin-skinned tectonics", an idea originated by structural geologists working in the southern part of the Appalachians during the early part of this century. Thin-skinned tectonics, a term coined by Appalachian geologist John Rogers in the late 1940's, refers to the idea that deformation in the mountain system affected only the sedimentary rocks lying on top of the crystalline basement. Huge, low-angle thrusts faults with miles of displacement separate the deformed sedimentary strata from essentially undeformed basement rocks. This concept opposed the old idea, termed "thick-skinned tectonics" by Rogers, that folding and faulting occurred in the basement rocks and that

Figure 1. Location and extent of the "Eastern Overthrust Belt" (Appalachian Mountains.



the overlying sedimentary rocks are only secondarily folded and faulted in imitation of the basement. Many well-known Pennsylvania geologists of the first half of the 1900's, including George H. Ashley and Richard E. Sherrill, were adherents of the thick-skinned concept. Both maintained that the sediments in the fold belt are too weak to support their own weight; therefore, the basement must be involved. Thick-skinned tectonics is illustrated in Figure 2A.

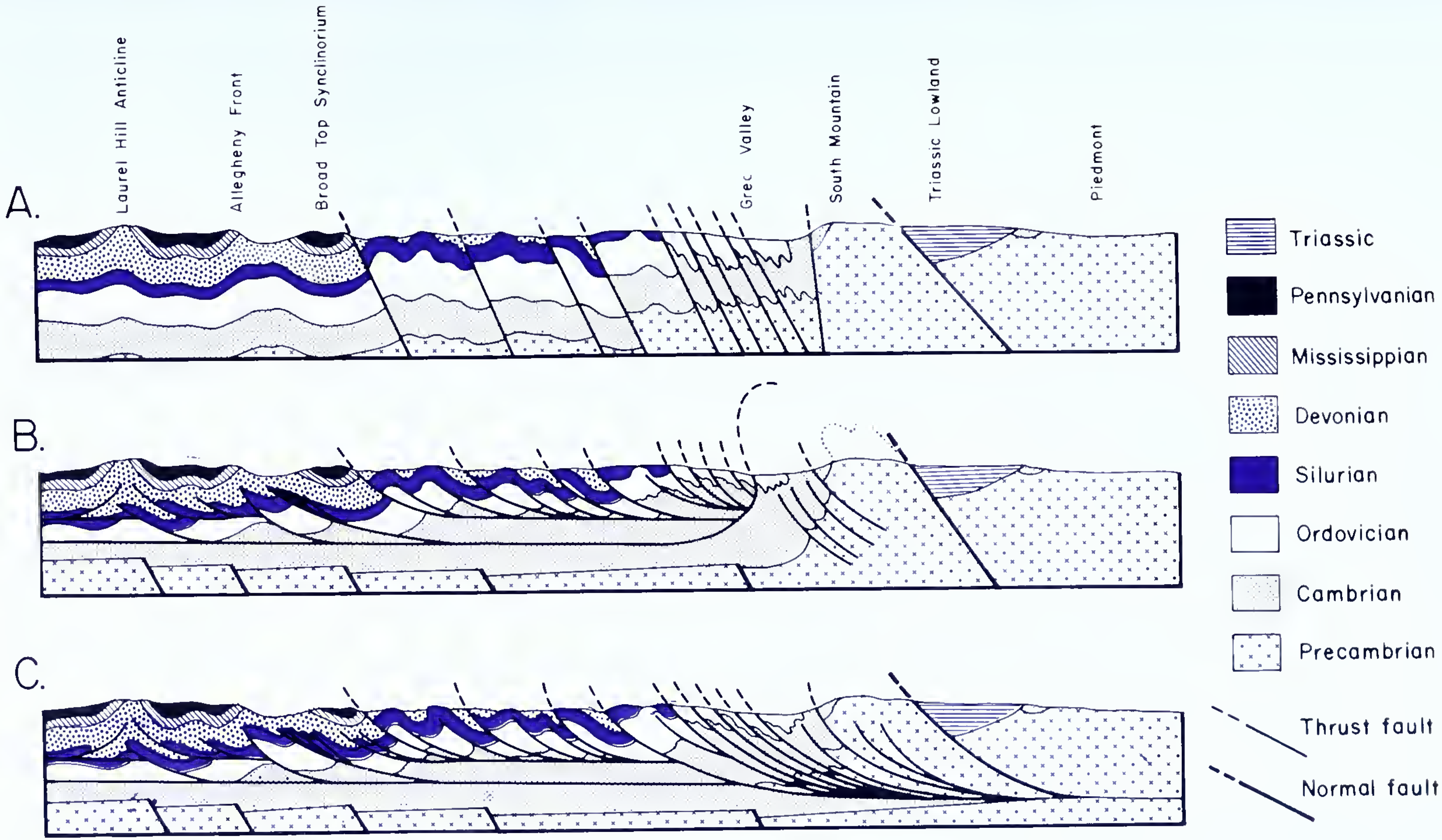
Thin-skinned tectonics (Figure 2B) became a working hypothesis when geologists needed a model to explain what appeared to be shortening of sedimentary rock packages across vast distances. The Valley and Ridge and Blue Ridge provinces in the southern Appalachians are approximately 150 kilometers wide at present, but according to geologists working in that part of the country the area was originally about 450 kilometers wide when the rocks were deposited. Was a block of rock 300 kilometers wide simply removed? If so, where did it go? According to the thin-skinned tectonics concept, the rock layers farther to the east shoved over the western rocks, pushing them into the subsurface as pressures were applied by the colliding North American and African plates. Dozens of subhorizontal and low-angle thrust faults, many of which extend to the surface, carried eastern rocks over western rocks in a series of imbricated sheets, similar to shuffling a deck of cards. This is especially apparent in the southern Appalachian Mountains where surficial geologic structure is dominated by thrust faults. In the central Appalachian Mountains, especially in Pennsylvania, the thrusts faults remain deeply buried for the most part and folding dominates

Figure 2. Generalized cross sections across southern Pennsylvania, illustrating the evolution of a concept. Not to scale.

A. Thick-skinned tectonics, in which the crystalline basement rocks (Precambrian) are folded and faulted, and the "weak" Paleozoic sedimentary rocks drape over these structures in imitation of them.

B. Older thin-skinned tectonics concept, in which the folding and faulting occurs in the sedimentary rocks and the basement is generally not involved; the Blue Ridge (South Mountain) and Piedmont are rooted in the basement and the major detachment fault rode up over them without affecting the crystalline rocks.

C. Newer thin-skinned tectonics concept, the "Eastern Overthrust Belt" idea, in which the structural styles are similar to the older concept (B), but the Piedmont and Blue Ridge are also involved; these crystalline rocks are shown thrust up over Cambrian sedimentary rocks.


Laurel Hill Anticline
Allegheny Front
Broad Top Synclinorium
Grec Valley
South Mountain
Triassic Lowland
Piedmont
A.
B.
C.
Triassic
Pennsylvanian
Mississippian
Devonian
Silurian
Ordovician
Cambrian
Precambrian
Thrust fault
Normal fault

the surface structure. Because of this, thin-skinned tectonics had a more difficult time being accepted in the north.

The thin-skinned concept, although embraced by a wide range of geologists, was nevertheless speculative in nature until limited drilling began in the Valley and Ridge Province in the 1950's. This drilling provided essential evidence to strengthen the general thin-skinned hypothesis, inasmuch as some wells were deep enough to penetrate multiple layers of rocks separated by faults. However, the concept remained relatively unconfirmed until the development and improvement of seismic exploration techniques. Seismic profiles across the Appalachian fold belt in all of its segments have given much credence to the thin-skinned model, and it is safe to say that there is general agreement among geologists to its validity throughout much of the Appalachians. However, the limits of the affected area have yet to be established.

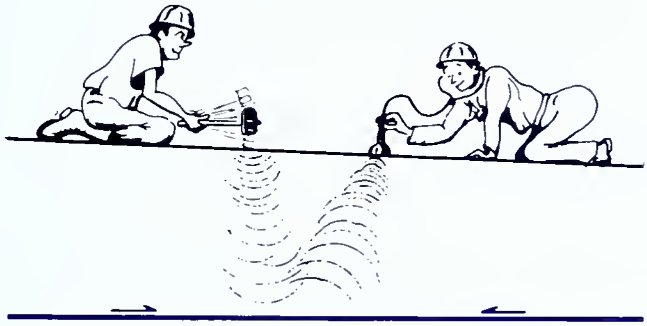
The current excitement over the not-so-new concept of the "Eastern Overthrust Belt" comes as a result of three recent developments. Probably the most important of these was passage of the Natural Gas Policy Act (NGPA) of 1978 which encourages escalated exploration of high cost natural gas by gradual deregulation of gas prices. The recent acquisition and published evaluation of high-resolution seismic reflection data in the eastern portion of the southern Appalachian region is a second major development. The third is the discovery of large amounts of oil and natural gas in the "Western Overthrust Belt", an area of the Rocky Mountains structurally similar to the "Eastern Overthrust Belt".

Geophysical information, acquired from seismic surveys especially, locally confirms and regionally refines some aspects of the thin-skinned tectonics hypothesis. Innovative interpretations of these data have opened up whole new ideas on the origin and developmental history of the Appalachians. Recent surveys in Tennessee, Georgia and Virginia indicate reflective horizons beneath the Piedmont and Blue Ridge which have been interpreted as subhorizontal sedimentary rock layers. These interpretations indicate overthrusting has also affected the crystalline rocks in the eastern Appalachian provinces of the Southern Appalachians; there they have become detached from basement and thrust over more westerly Early Paleozoic rocks (Figure 2C). This would make it feasible for companies to drill through the crystalline rocks east of the Valley and Ridge and still encounter sediments, and perhaps petroleum deposits as well, at depth. In such a case the depth would probably be 30,000 to 40,000 feet. We have had the opportunity to examine seismic data in the Appalachians, and especially in Pennsylvania, which seems to indicate the presence of this detachment structure

in the subsurface at least as far north as the southern most portion of Pennsylvania. The extent of the Blue Ridge detachment is not nearly so great this far north as in Georgia, but it appears to exist to some degree. Presence of seismic reflections east of this detachment probably represents fault zones rooted in the Precambrian basement. Many of the oil and gas companies have had information of this kind for at least 10 years. This accounts for some of the leasing and subsequent seismic surveying activity in the southeastern counties of Pennsylvania.

The age and structural complexity of the eastern Valley and Ridge, Great Valley, Blue Ridge, and Piedmont require a consideration of the thermal history of that portion of the "Eastern Overthrust Belt". Assuming that the Piedmont actually has been thrust tens or hundreds of kilometers westward, Paleozoic sedimentary rocks beneath it probably reached temperatures and pressures high enough to initiate at least low-grade metamorphism. Under such conditions most hydrocarbons in the rocks at the time would have reached the gaseous phase (e.g. methane) and been driven off into the atmosphere, or possibly into reservoirs in the cooler adjacent areas. Many geologists believe the heat and pressure to which those rocks were subjected probably removed any hydrocarbons which once might have been there. In other words, structurally the Eastern Overthrust Belt may exist, but may be barren of oil or gas.

However high the stakes may be, the petroleum industry appears prepared to wager huge sums of money to drill deep wells in the "Eastern Overthrust Belt". Any such venture is a gamble, however, and in gambling terms industry has to study its cards carefully before upping the ante. So it is that residents in central and eastern Pennsylvania, as well as from other "non-productive" areas, should expect more and more to receive requests for leasing and permits for seismic work as the next few years unfold. But only time and a lot of money will tell if the gamble was worth the risk. There may be oil or gas down there, or there may be none.



1982 EARTHQUAKES: CORNWALL HEIGHTS AND PENNDEL

by Richard E. Biscke
Temple University

On April 12 and May 12, 1982, the greater Philadelphia region experienced two more earthquakes. Since this is the second sequence of earthquakes in almost two years, the lower Delaware River Valley has been one of the most seismically active regions on the east coast during the last decade. The April 12, 1982 event occurred at 5:14 PM Eastern Standard Time and had a Nuttli magnitude of 2.9. This earthquake apparently occurred between the towns of Cornwells Heights, Pa. and Burlington, N.J. along the Delaware River (Figure 1). Thus the epicenter of the April 12 earthquake was very near the felt areas of the Sept. 10, 1877 and Dec. 27, 1961 earthquakes that affected the regions surrounding the towns of Bristol, Pa. and Burlington, N.J. (Abdypoor and Bischke, 1982). The May 12th event occurred at 12:01 Eastern Standard Time, was smaller than the April 12 earthquake, and was apparently centered near the town of Penndel, Pa., about 6 miles to the northwest of the April 12 earthquake.

Two years prior to these events the city of Philadelphia and its northern suburbs experienced 5 earthquakes, of which 3 were felt. The two largest of these earthquakes occurred on March 5 and 11, 1980 and had revised Nuttli magnitudes of 3.0 and 3.2, respectively. They were most strongly felt in the Abington, Glenside, Jenkintown, and Huntingdon Valley areas of Pennsylvania (Bischke, 1980). This is significant because the Huntingdon Valley fault, a very old but major tectonic dislocation (Tearpock and Bischke, 1980), runs through these cities. Penndel, Pa., the apparent center of the small May 12, 1982 event, is located on the Huntingdon Valley fault about 10 miles to the east of the epicenters of the March 5 and 11, 1980 earthquakes.

Immediately after the April 12 event a number of local and regional newspapers published an earthquake felt report questionnaire to test people's reactions to the earthquake. Of these questionnaires

222 and 139 were returned from the Pennsylvania and New Jersey areas, respectively. These data were analyzed at Temple University and a modified Mercalli intensity map was constructed for the April 12 event (Figure 1).

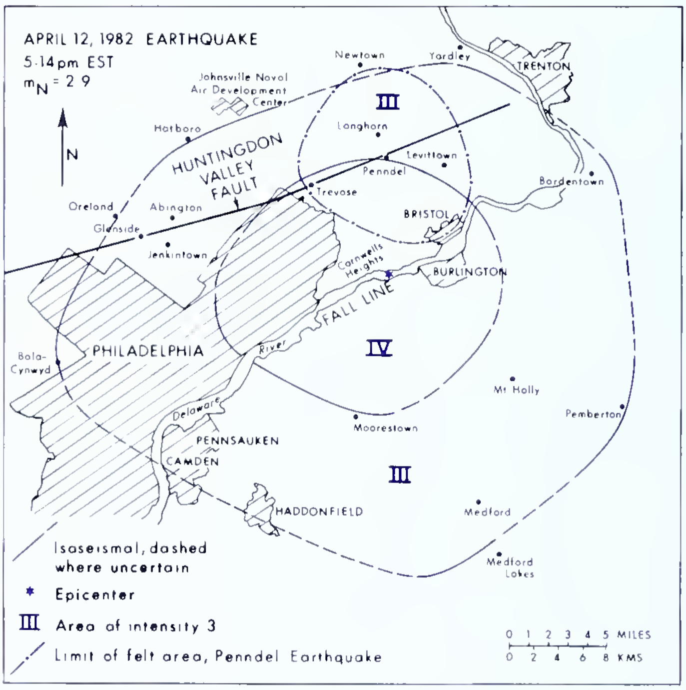
People living within the felt area both heard and felt the earthquake, and most people reported a trembling motion lasting from between 5 to 10 seconds. People's reactions to the earthquake varied, although most descriptions of what occurred at the time of the earthquake were remarkably similar. Many people described the earthquake as a distant explosion or boom; while others thought that their furnace or oil heater blew up, that a truck hit a pothole or a building, or that furniture was being dragged across the floor. In two other cases a vase overturned, and dishes moved slightly. In general, however, most people agreed that the 1982 event was not as intense as the 1980 events; that the earthquake shook the buildings in which they were located and that the windows often rattled. These descriptions place the April 12 event between intensity III to IV on the Mercalli scale, although intensity V was felt locally.

An examination of the isoseismal map (Figure 1) shows that the earthquake was felt from the Mt. Airy-City Line region in western Philadelphia to Pemberton, N.J. in the east, and from the Newtown-Yardely, Pa. areas in the north to the Medford Lakes, N.J. region in the south. This area corresponds to a region of 485 sq. miles. As a comparison, the magnitude 3.2 March 11, 1980 earthquake was felt over a 350 sq. mile area (See Bischke, 1980). How can the smaller magnitude 2.9 April 12, 1982 event be felt over a larger area than the magnitude 3.2 1980 event?

Two factors could contribute to the differences in the size of the felt areas. First, the 1982 earthquake may have occurred at a shallower depth than the 1980 earthquake, although many people also reported hearing the 1980 events. This suggests that all of these earthquakes were shallow earthquakes. Second, an examination of the Isoseismal map of the Aug. 22, 1938 Central New Jersey earthquake (Neumann, 1940) reveals that the isoseismals over the *unconsolidated* or soft coastal plain sediments, which exist to the south of the Delaware River, are deflected far to the east or southeast and towards the New Jersey shore. To the north of the Delaware River the rocks are *crystalline* or hard, being composed of Wissahickon schist and Precambrian gneisses. Here the isoseismals of the 1938 earthquake trend east northeast and are most compact and closer together. Thus it appears that the unconsolidated coastal plain sediments of New Jersey are more capable of transmitting high amplitude waves over larger areas than are the crystalline rocks to the north of the Delaware River. As the epicenter of the April 12 earth-

quake was near the Pennsylvania-New Jersey border, and as the earthquake was felt over a larger area of New Jersey than of Pennsylvania, the isoseismal map (Figure 1) seems to confirm the above

Figure 1. Isoseismal map for the April 12, 1982 earthquake and the probable May 12, 1982 earthquake. The isoseismals, or lines of equal apparent intensity of ground shaking, are dashed where the data is uncertain. Notice that the isoseismals cover a larger area of New Jersey than of Pennsylvania, even though the isoseismals appear to be elongated parallel to the Delaware River or the Fall Line. The epicenter of the April 12 event was determined from seismic stations located at Newark, Del., Princeton, N.J., and at Millersville and Kutztown, Pa.



conclusion. This can best be seen by first placing a sheet of paper along the Fall Line on figure 1 and covering the state of New Jersey,

and then repeating this process by covering the state of Pennsylvania.

Since the Greater Philadelphia region has had a history of twin or multiple earthquakes, twin earthquakes occurring in this region on March 17 and Nov. 29, 1800, Nov. 11 and 14, 1840, and on March 5 and 11, 1980 (Conrad and Geyer, 1971; Abdypoor and Bischke, 1982); The Delaware Valley earthquake research team, in conjunction with Penn State University, installed a portable microearthquake seismograph (MEQ 800) at the Johnsville Naval Air Development Center (see Figure 1). This instrument recorded a small event on May 12, 1980 at 12:01 PM which occurred 8 miles away from the Naval Air Development Center. At precisely this time Police stations and a local newspaper located near the towns of Bristol, Levittown, Newtown, Trevose and Penndel, Pa. reported receiving numerous telephone calls complaining about an explosion and earth tremors. This area is outlined by the dashed line region on Figure 1. As Penndel, Pa. is located 8 miles from the Naval Air Development Center, and as this town is located in the center of the felt area of the May 12 event, Penndel is the likely center for this probable earthquake. A more accurate location for this event is not possible as it was apparently too small to be recorded at more distant seismic stations.

It appears possible that the Huntingdon Valley fault was responsible for the May 12 event. Residents within the felt area reported hearing an explosion and/or feeling their houses shake. Thus the May 12 event was on the order of Mercalli intensity III.

Therefore the Greater Philadelphia region appears to have two active fault lines: the Huntingdon Valley fault to the north of the city and the Fall Line fault beneath the Delaware River. The Feb. 28, 1973 (M = 3.8) Wilmington, Delaware, and Dec. 27, 1961 Pennsylvania-New Jersey earthquakes support this conclusion. The Wilmington, Delaware earthquake was located adjacent to the city of Wilmington and directly beneath the Delaware River (Sbar, et al., 1975). Thus the Fall Line lineament, which runs from northern Virginia to New York City, seems to have been responsible for the April 12, 1982 earthquake.

ACKNOWLEDGEMENTS

I am extremely indebted to V. Sakovich and G. Abdypoor of the Delaware Valley earthquake research team for their help in understanding these earthquakes. I would also like to thank Dr. S. Alexander, Dr. K. Woodruff, Dr. C. K. Scharnberger, E. Schlesinger-Miller, and N. Barstow for supplying me with seismic information.

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Dr. Edgar T. Wherry

Pennsylvania has lost a distinguished scientist and major contributor to geological knowledge in the death of Edgar T. Wherry on May 19, 1982. With an undergraduate degree in chemistry and his doctorate in mineralogy (from Penn), Professor Wherry went on to become a distinguished botanist at Penn, an outstanding mineralogist at the U.S. National Museum and U.S. Department of Agriculture, and an enthusiastic field geologist, with frequest contributions to the geologic data that was being assembled at the Pennsylvania Geologic Survey. Dr. Wherry was a prolific author, active in each of his fields of interest, and so very capable of bringing together the diverse sciences as a true naturalist. Almost to his passing at age 96, we continued to receive notes from him on his latest geologic thoughts and concepts.

The Pennsylvania Survey is privileged to have known Dr. Wherry as a friend and co-worker.

EARTH SCIENCE TEACHERS' CORNER

a unique teaching tool

Kutztown State College has a quarry!

by William Kreiger
Kutztown State College

Although the quarry was purchased with a large tract of land in 1970, much of the campus population is not aware that it is part of the Kutztown State College campus. The five acre quarry is located on the southern limits of the campus behind Keystone Gymnasium and South Dining Hall. It is not in commercial operation, but it is being utilized by students of geology. Kutztown State College is fortu-

Figure 1. The southeast wall of the quarry bench showing fault zone, solution cavities, and bedding among other sedimentary features.

nate to have this extraordinary facility for the quarry has a multitude of uses in geology, environmental science and biological science.

It is a "hands on" learning tool and several quarry related laboratory exercises have been developed by the geology instructors. Some features of sedimentary rocks to note in the quarry are bedding, jointing, mudcracks, fossils, and solution cavities. Structural features include fault zones and folds (Figure 1). The ground-water table level and the water table fluctuation can also be observed here.

The exposed rock is Ordovician limestone of the Beekmantown Group, the Epler Formation. It formed from limy sediments deposited in a warm water marine environment about 450 million years ago. Limestone blocks construct the foundation of Old Main (Figure 2) and other buildings on the campus. These blocks of limestone building stone could have come from this quarry.

An instructional tool realized by few educational institutions, the quarry can be very important and useful in achieving educational goals at Kutztown State College. It appears that the quarry is only beginning to be realized for its potential educational value. Credit must be given to the foresight of the President, Board of Directors, administrative staff, and faculty for an applied learning opportunity.

Figure 2. The Keystone Normal School limestone cornerstone dated 1892 at the entrance to Old Main.

MOODS OF THE SUSQUEHANNA

by John P. Wilshusen
Pa. Geological Survey

We well remember the devastation of Hurricane Agnes ten years ago but we tend to forget the changing moods of the Susquehanna River as it flows by our doors.

Sometimes the flow of the river is so low that it seems to have stopped altogether as might be imagined from this photo (Figure 1) near Wrightsville, October, 1980. At other times the channel is filled to overflowing as is shown in Figure 2 taken in Harrisburg, September, 1975. Most interesting perhaps is part of the river turning solid with thick slabs of ice buckling into ice ridges reminiscent of the Great Ice Age which left Pennsylvania only about 12 to 13,000 years ago (Figure 3). The catastrophism that the pictured geologist is thinking about is an idea that sudden, violent, short-lived events have greatly modified the Earth's crust.

Figure 1. The Susquehanna River at Wrightsville during a period of low flow, October, 1980.

Figure 2. The Susquehanna River at Harrisburg during a period of high flow associated with tropical storm Eloise, 1975.

Figure 3. Prominent Pleistocene geologist (W. D. Sevon) contemplates catastrophism while seated in River Front Park, Harrisburg, January, 1982. Photo by J. P. Wilshusen.

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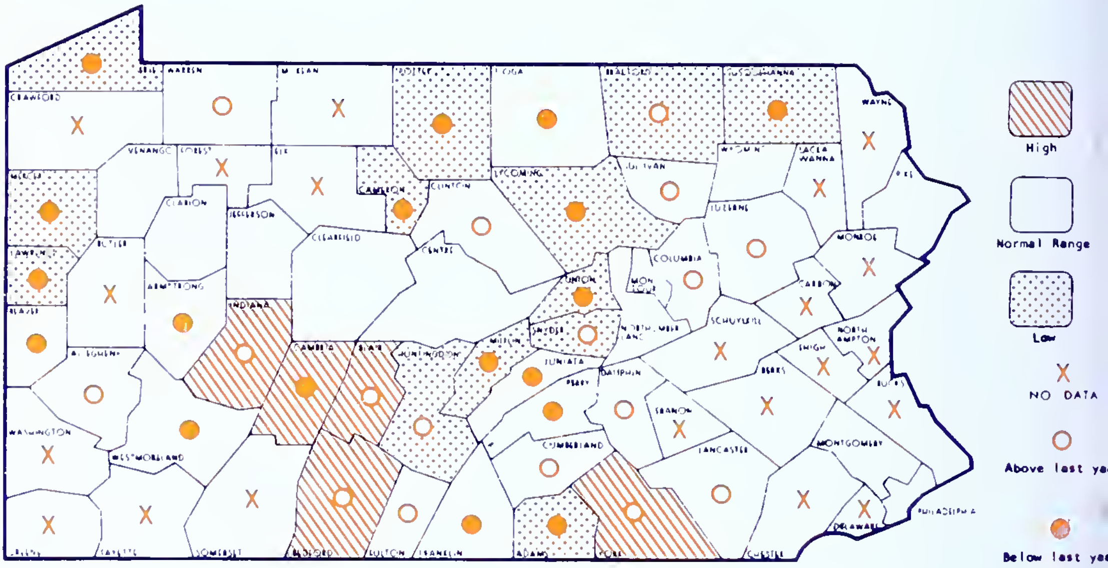

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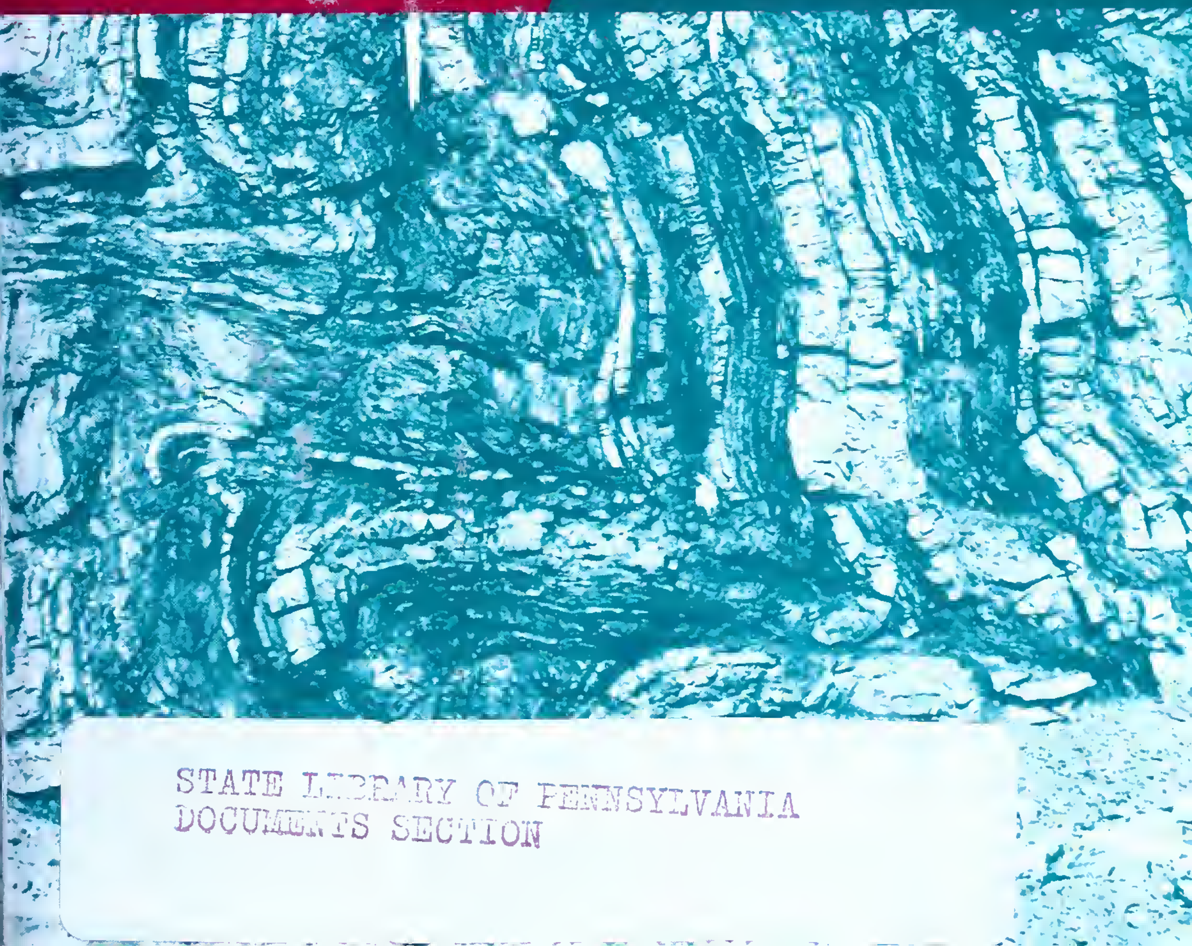

COMMONWEALTH OF PENNSYLVANIA
Richard L. Thornburgh, Governor

DEPARTMENT OF ENVIRONMENTAL RESOURCES
Peter S. Duncan, Secretary

OFFICE OF RESOURCES MANAGEMENT
R. Timothy Weston, Associate Deputy Secretary

TOPOGRAPHIC AND GEOLOGICAL SURVEY
Arthur A. Socolow, State Geologist

CONTENTS

ON THE COVER: Complex folding and faulting in Tuscarora Formation (with interbedded shale) at east end of Laurel Creek Reservoir dam, visible from U.S. Route 322, 10 miles north of Lewistown, Mifflin County, PA. Photo view facing east; upper portion has been moved northward (left) along low angle fault which cuts through the fold. Photo courtesy of Rodger Faill.

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Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

December 1982

FROM THE DESK

OF THE

STATE GEOLOGIST . . .

ON PICKING NEW PROGRAMS AND PROJECTS

Periodically, as staff members complete their Survey projects, we reassess the geologic work that's waiting to be done in Pennsylvania so as to properly focus on those projects that truly merit priority attention.

Yes, there is a great deal yet to be done: approximately 30 percent of the State has yet to be geologically mapped in detail — the reconnaissance mapping which has been done in these areas does not provide the specific data needed for forthcoming construction activities, land use planning, or environmental protection and hazards control. Even some areas already mapped in detail need to be reexamined in light of new techniques and new geologic concepts.

We have work yet to do on a thorough understanding of the industrial minerals (coal, limestone, clay, silica, etc.) which are supporting our economy as well as the showings of the more exotic, strategic minerals (chrome, cobalt, nickel, etc.) for which our nation is now dependent upon foreign sources.

There is work to be done yet on our ground water resources, the Commonwealth's highly underutilized water resources, particularly valuable in light of the threatening reoccurrence of drought conditions in portions of eastern U.S.

And of course there's so much more we need to know about our oil and gas resources as new exploration demonstrates that there remains untapped oil and gas at depths and in areas heretofore untested.

With all that geologic work waiting to be done, and with a limited staff and budget, we have to choose our new project work on an objective, priority basis. Criteria which we use to establish priority are: (1) There should be a demonstrated need for the geologic information by Pennsylvania users (i.e. the public, industry, other government agencies) who, as taxpayers, would benefit by the new data. (2) We would have to have existing, qualified staff members whose expertise is appropriate to the project and who would be available to undertake a new project. (3) The project should have geologic significance, worthy of the efforts of the high caliber professional staff. (4) The project would have to be completable in a reasonable length of time so that the user public does not grow old and tired waiting for results. (While geologic projects are invariably lengthy, no project should be planned for more than 3 years duration — preferably less.) (5) Any new project must avoid duplicating work done by others, such as the academic community or federal agencies. (6) A project must be financially affordable, within the existing budgetary constraints that affect available manpower and equipment.

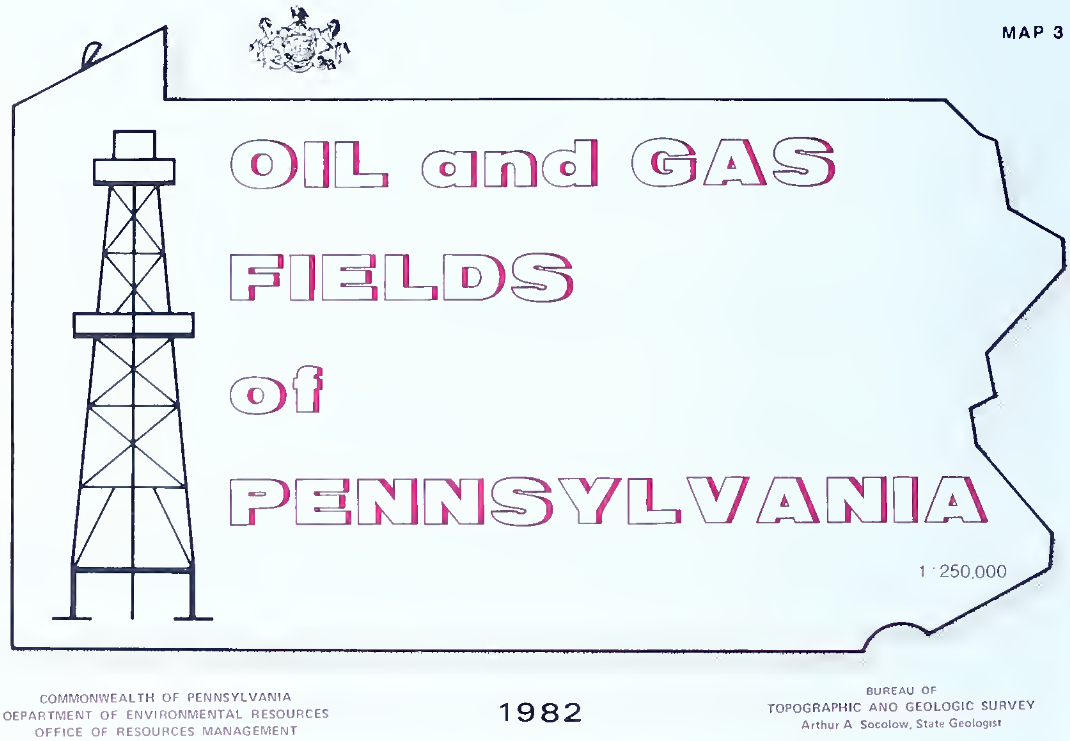
I share the above with you, in part to make our friends and users aware of how program and project selections are made, but especially to invite all who are interested to provide input, to share with this office your needs, your interests, and your comments. The intent is to assure that the operating program of the Bureau of Topographic and Geologic Survey is truly responsive to the needs of our Commonwealth Community.

Arthur A. Socolow

NEW OIL AND GAS FIELDS MAP PUBLISHED

One thousand seventy seven (1,077) oil and gas fields and pools in Pennsylvania are shown on the new edition "Oil and Gas Fields Map of Pennsylvania", Map #3, which has been published by the Bureau of Topographic and Geologic Survey. This map delineates all areas of Pennsylvania that have produced oil and gas up to July 1, 1981. It is the most detailed and up-to-date map available of Pennsylvania's oil and gas fields, including commercial gas storage fields.

As an innovation, the map shows the primary oil and gas bearing rock formations from which the oil and gas are produced in each field shown on the map. Previous maps of this kind have not included this reservoir information. Thirteen major reservoir units are identified and are shown by pattern and tones of the primary colors — green for oil fields and red for gas fields. Individual formations and drillers' sand names are listed in the legend. This map will be of great benefit to all concerned in any way with Pennsylvania's oil and gas exploration, production, and management.



Map #3, "Oil and Gas Fields Map of Pennsylvania", may be obtained by sending the proper amount to: Dept. of General Services, State Book Store, P.O. Box 1365, Harrisburg, PA 17125. The cost of Map #3 is $3.40 over the counter plus $.21 tax for Pa. residents. If the report is to be mailed, the price is $4.20 plus $.26 tax for Pa. residents. Checks should be made payable to "Commonwealth of Pennsylvania".

The new detailed oil and gas fields map is published at a scale of 1:250,000 and includes two sheets. Map #3 was preceded by publication of a completely revised Geologic Map of Pa. (Map #1), published at the same scale on two sheets in 1981, which is also available from the State Book Store at $9.00 per copy (including postage) plus $.54 tax for Pennsylvania residents.

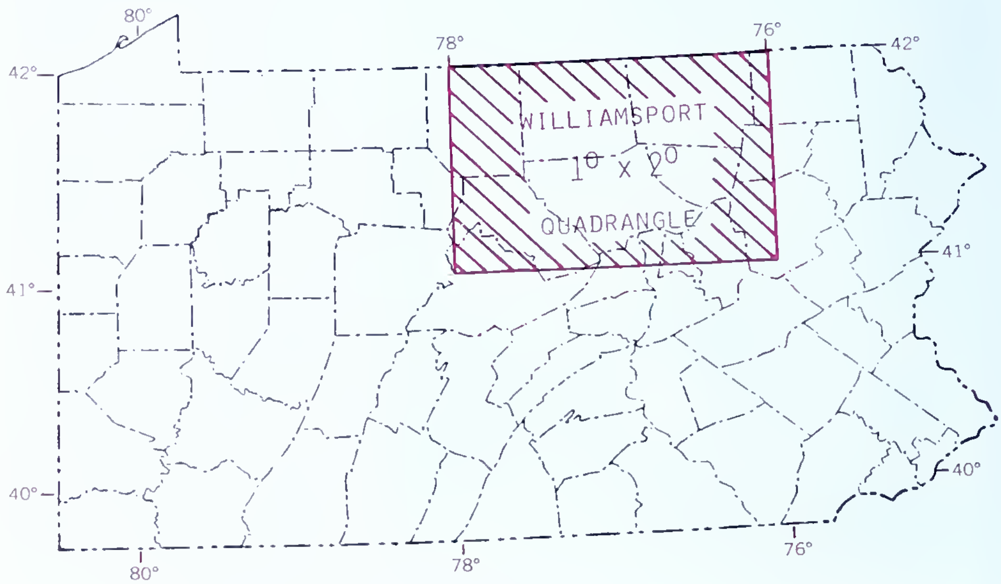
All in a day's work

State Geologist Dr. Arthur Socolow faces the task of reviewing a new set of industry data on natural gas wells as part of the Bureau of Topographic and Geologic Survey's responsibilities under the Natural Gas Policy Act.

WILLIAMSPORT AREA LANDSLIDE STUDY

The Pennsylvania Geological Survey and the U.S. Geological Survey have begun a jointly funded investigation of landslide susceptibility in the area covered by the Williamsport 1° × 2° quadrangle. This covers Lycoming, Sullivan, Tioga, Bradford and Clinton Counties, plus portions of Potter, Wyoming, Columbia, Montour, Northumberland, Centre, and Luzerne Counties. The principal investigators are John P. Wilshusen and Helen L. Delano, both of the Environmental Geology Division of the Pennsylvania Geological Survey. The project is an extension of the program initiated by the U.S. Geological Survey in assessing landslide susceptibility in the Appalachians from Alabama to western Pennsylvania. (See *Pennsylvania Geology*, Vol. 13, #3, for a description of the open-file landslide inventory maps from this work in western Pa.)

The major phases of the project include: an aerial photographic and field survey to inventory areas of previous landslide activity and develop a classification system for slide related features; detailed surficial mapping of selected small areas; correlation of known slides with bedrock, structural and surficial geology; and preparation of a map of landslide hazard areas based on these correlations. The work is presently in the aerial photo and field survey phase.



The study area, which covers 128 seven and a half minute quadrangles, includes Paleozoic rocks of the folded Appalachians, dissected flat-lying sandstones and shales of the Appalachian Plateau, and Wisconsinan and Illinoisan age glacial deposits. Forestry and agriculture are by far the most prevalent land uses within the area. With increasing development pressure, and the accompanying need for roads, utility and pipe lines, and good building sites, there is a need for information about landslide risk. This information will be useful as a guide for planners, developers and engineers in predicting slope stability conditions within the study area. No regional report can substitute for detailed, site specific investigations, but it can be used to indicate areas where closer study is required, and for planning and preliminary site selection purposes.

pennsylvania geopics

Tree and utility pole topped residual mounds resulting from earth removal for a nearby construction project. Future archeologists may well wonder why the 20th century natives chose to plant their trees and telephone poles on mounds. Photo courtesy of William Kreiger, York, Pa.

The base-flow frequency curve as a groundwater management tool in Pennsylvania

by Larry E. Taylor and
William H. Werkheiser
Pa. Geological Survey

Frequency curves have had many uses in hydrology. They have, for example, been used to show the frequency of floods, low flows, and intensities of rainfall. In essence, a frequency curve relates the magnitude of a variable, such as streamflow, to its frequency of occurrence. The frequency of an historical flow as determined from the curve is often used to predict the probability of future flows of the same magnitude.

The reliability of a frequency curve depends on several factors, the most important of which is the number of events or data points used to prepare the curve. In general, the frequency of annual stream flows can be computed reliably for many drainage basins because records for a large number of years are available. Accumulation of a large number of annual base flows, however, can be quite time consuming because base-flow data must be separated manually from stream hydrographs. This article presents a method to limit the number of hydrograph separations needed to prepare a reliable base-flow frequency curve and describes how the curve may be used as a groundwater management tool.

The method relies on using the more abundant stream-flow data (total runoff) to determine the plotting position, or frequency, for the base-flow data (base runoff). In order for this approach to be valid the base flow for a given year must be directly related to the total runoff for the same year. Figures 1 and 2 show the correlation between total flow and base flow for two drainage basins in central Pennsylvania. The closeness of fit and the high correlation coefficients obtained from the data suggest that the method should be effective.

The frequency of annual runoff was computed and plotted on normal probability paper for Spring Creek and the West Branch of the Susquehanna River as measured near Karthaus for the 40 year

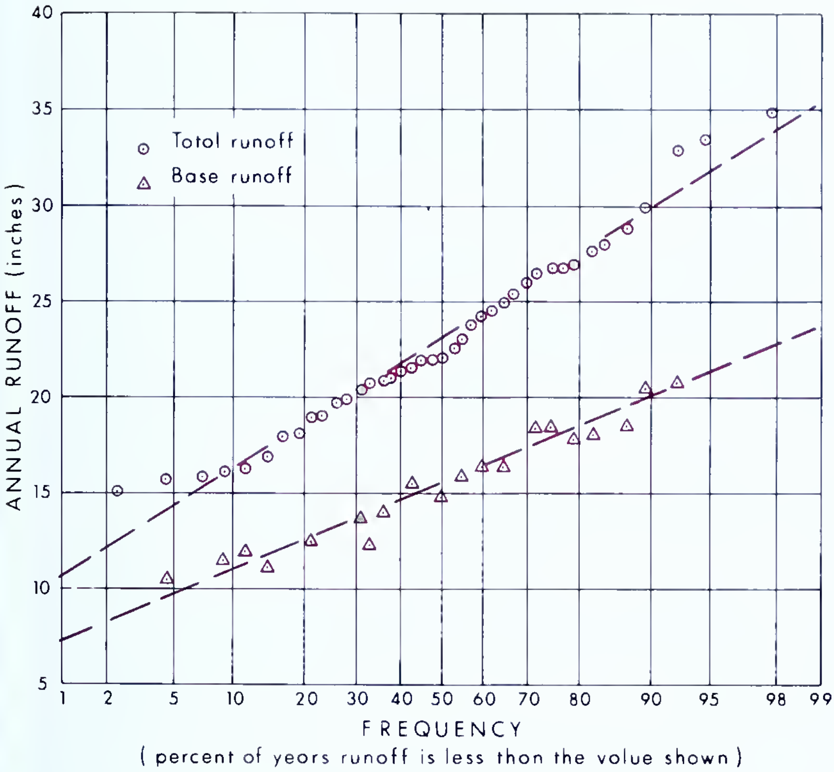


Figure 1. West Branch runoff at Karthaus (1941-1980)

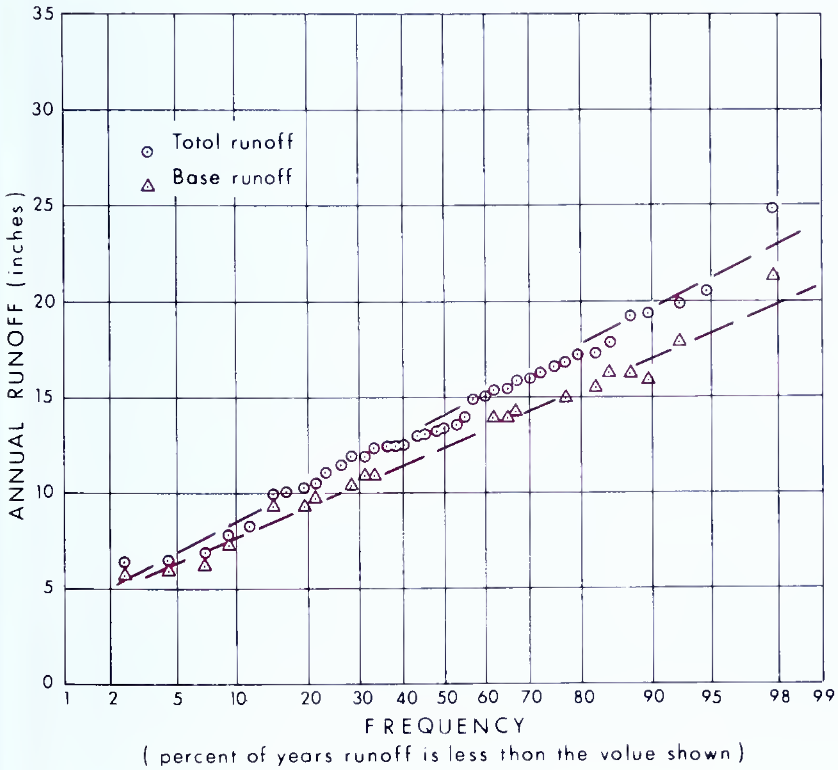


Figure 2. Spring Creek runoff near Axemann (1941-1980)

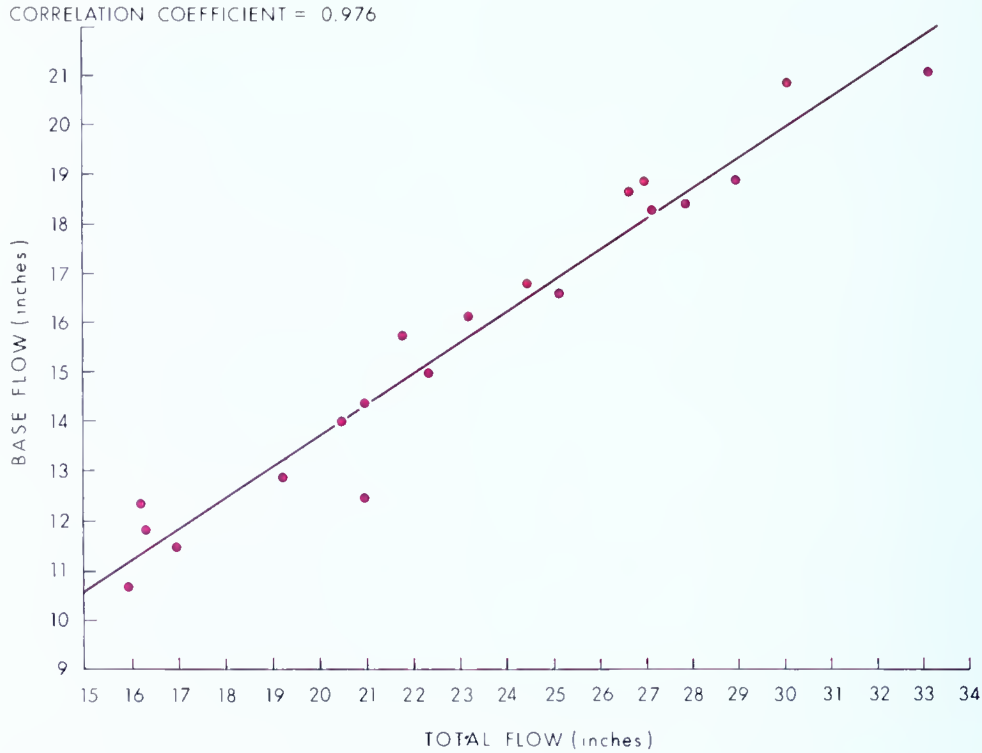


Figure 3. Total flow versus base flow for the W. Branch near Karthaus (1961-1980)

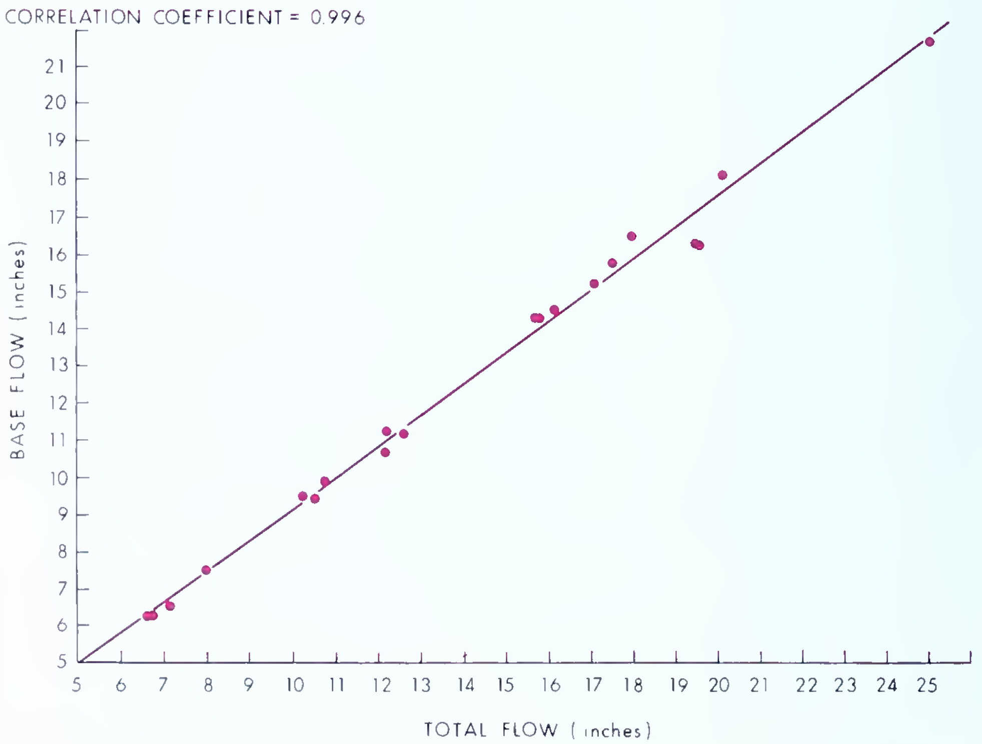


Figure 4. Total flow versus base flow for Spring Creek near Axemann (1961-1980)

period 1941 to 1980. These basins were analyzed because of their diverse geology; the West Branch of the Susquehanna River at Karthaus drains relatively flat-lying sandstone and shale, and Spring Creek drains highly folded and faulted carbonate rock. Base flow separations were made using standard techniques for the years 1961 to 1980 (20 years). This time span was selected because it incorporates one of the driest periods of record (the 60's) and one of the wettest periods of record (the 70's). Base-flow data were then plotted at the frequency position of the corresponding total-runoff values. Figures 3 and 4 show the results of this analysis. Note that the 20-years selected for base-flow separations give a wide range of frequency values.

Two uses are suggested for the base-flow frequency curve. Existing groundwater use within a basin can be compared with base-flow values on the frequency curve to estimate the potential for groundwater shortages. This is done by converting annual groundwater use to inches and locating the equivalent quantity on the annual runoff scale of the graph. A horizontal line is drawn from this point to determine if an intersection with the base-flow frequency curve exists. If there is an intersection, a vertical line drawn from the point intersection to the horizontal axis will give the frequency at which groundwater use is equal to base flow. Any time groundwater use equals or exceeds base flow, water-supply problems are likely to be experienced in many parts of the basin.

Secondly, base-flow frequency can be used in water system design. For example, designers of a proposed water system might want it protected against a 50-year recurrence-interval base flow (drought). The areal base flow (which is essentially equivalent to areal recharge) could be computed from the curve using the base-flow value corresponding to the 2 percent frequency. The approximate size of the area from which recharge must be captured to withstand such a drought could then be calculated and the well field designed accordingly.

A useful feature of this technique is that the base-flow curve can be updated annually without performing any new base-flow separations by simply incorporating new stream-flow records as they become available into the total-runoff plot. The plotting positions of the base-flow data are then changed to fit the new annual runoff positions, thus establishing a revised curve.

The base-flow frequency curve as derived in this report is not proposed to be a substitute for more rigerous groundwater management techniques such as analytical and digital modeling. However,

it can be useful in the establishment of preliminary management guidelines and thereby be a useful tool to groundwater managers.

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A GUIDE TO OBTAINING INFORMATION FROM THE USGS, 1982

Since 1879 the US Geological Survey has served the public by collecting, analyzing, and publishing information about the Nation's mineral, land and water resources. This information is available in map, book and other formats and is for sale from within and outside the USGS.

A guide has been prepared to assist in obtaining these products and also to direct the public to information sources. Besides general instructions for ordering maps and books by mail, the Guide consists of three parts:

1. A description of the offices from which information is available. This section includes sources for general information within USGS, for information on specialized subject, for information about USGS publications, and for information on specialized reports. Also included are USGS libraries and other libraries where USGS publications can be consulted.
2. A list of the types of USGS maps, reports, and other products and the locations where these products can be obtained.
3. A list of the sources of USGS maps, reports, and other products, arranged alphabetically by the codes used in the list of products, and their addresses and commercial and government telephone numbers.

A Guide to Obtaining Information from the USGS, 1982 — USGS Circular 777 — is available free by writing Eastern Distribution Branch, Text Products Section, US Geological Survey, 604 South Pickett Street, Alexandria, Virginia 22304-4658.

International Group of Geologists Tour Pennsylvania

A group of 17 geologists from around the world recently spent 6 days examining Upper Ordovician and Upper Devonian rocks in Pennsylvania. The group was composed of three people each from China and the United States, two each from Tunisia and South Africa, and one person each from Brazil, Canada, England, France, Japan, New Zealand, and Singapore. All were participants in a field excursion following the 11th International Congress on Sedimentology held in Hamilton, Ontario, August 22-27, 1982. The excursion, entitled "Comparative sedimentology of Paleozoic clastic wedges in the Central Appalachians, U.S.A.," was led by Allan M. Thompson, University of Delaware, and William D. Sevon, Pennsylvania Geological Survey. The trip comprised 16 stops in Pennsylvania between Kinzua Lake in Warren County and Delaware Water Gap, with numerous stops near Milesburg and Lewistown, along the Susquehanna River north of Harrisburg, and along the Lehigh River between Palmerton and Jim Thorpe.

Field trip group at Ordovician carbonate outcrop near Reedsville.

Although the emphasis was primarily on examination of the selected outcrops, the group also enjoyed an open house at the Pennsylvania Geological Survey, a visit to a typical American shopping center, and sight-seeing in Jim Thorpe. Cooperative weather, excellent group congeniality, great rocks, and no logistical failures combined to create a memorable experience for all the participants.

In Memoriam, Colonel Thomas W. Myers

Retired Colonel Thomas W. Myers, a friend and associate of the Pennsylvania Geological Survey for many years, died August 14, 1982. He contributed a great deal of his time and talent to the advancement of knowledge of Pennsylvania mineralogy through his photography.

Born and raised in Altoona, he graduated from Ursinus College in engineering and served 23 years with the U.S. Army. Following his retirement from the service, he worked 14 years as a civil engineer for the Commonwealth's Department of General Services. In his spare time, he actively pursued his interest in geology, mineralogy and mineral photography.

Colonel Myers spent many hours photographing mineral specimens for Survey reports including *Mineral Collecting in Pennsylvania* (Gen. Geol. Rept. 33) and *Zinc and Lead Occurrences in Pennsylvania* (Min. Res. Rept. 72). Most recently, he photographed specimens collected for the soon-to-be released report *Copper and Uranium Occurrences in the Picture Rocks and Sonestown Quadrangles* (Min. Res. Rept. 80). In addition, he provided the difficult ultraviolet fluorescence photography for *The Mineralogy of Pennsylvania 1966-1975* (published by Friends of Mineralogy, Pa. Chapter, 1976).

He was a member and director of the Pennsylvania Chapter of the Friends of Mineralogy and had recently finished putting together a set of color slides of most of the known mineral species in Pennsylvania for the club. Always willing to be of service, Colonel Myers and his work will be missed by the geologic community.

Fossils From The Larksville Mine Fire

by William F. Klose, II

Excavation of the mine fire in the top and bottom split of the Ross anthracite seam northeast of Larksville, Luzerne County, Pennsylvania (Figure 1) has provided a unique opportunity to examine the flora and fauna contained in the roof shales and underclays associated with this classic Pennsylvanian (Upper Carboniferous, Allegheny Series (Upper Westphalian D)) coal. The mine fire is believed to have originated in refuse from the June, 1972 flood in the Wyoming Valley that was buried in old strip mines used as emergency land fills during the flood clean-up effort.

The 25-acre mine fire site is being encircled by a trench which is backfilled with fine sand to block the fire advance. The material excavated from the trench is watered down by hydraulic jets (Figure 2) that use deep mine water to extinguish any burning coal or debris, and is then hauled to an adjacent rock dump. The entire 25 acres will be excavated to extinguish the fire.

At the mine fire site, the lower split of the Ross seam is 6 to 7 ft. thick and is separated from the underlying Red Ash seam (top split) by 50 ft. Twenty feet of blocky underclay containing lycopod rootlets (*Stigmaria* sp.), and horsetail pith casts (*Calamites* sp.) separates the 3- to 4-foot-thick upper split of the Ross seam from the

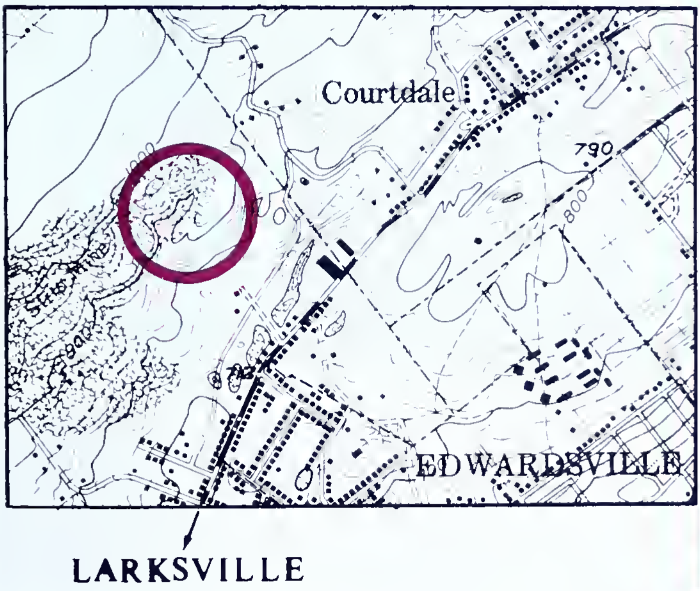

Figure 1. Location of mine fire site northeast of Larksville.

lower split. Both the upper and lower split were deep mined, leaving pillars of coal for roof support; they were later strip mined along the western edge of the site along the outcrop line. The roof rock above the top split grades gradually upward from very fissile (fine bedded) shale containing lycopod (relatives of the modern ground pine of Pennsylvania) bark impressions and horsetail (*Calamites* sp.) remains, to sandy shale containing a diverse flora, to sandstone containing occasional seed fern stems. This roof rock sequence is a fairly typical association of the Allegheny series anthracite coals of northeastern Pennsylvania.

Adjacent to the fire and where hot gasses from the mine fire pass up through fissures in the overburden, the grayish-black matrix turns into an orangish-red porcelain-like material. Fossils are rare in most of the excavation and are usually fragmentary, but careful search has produced an extensive list of species (Table 1). All of the species are typical of the Pennsylvanian Allegheny Series swamp environment.

The fossil specimens were collected through the courtesy of the contractor, Kaminski Brothers, and will be deposited with the William Penn Memorial Museum in Harrisburg. Mr. Andy Oherko of the Mine Safety and Health Administration provided details on the stratigraphy of the mine fire site. Dr. William Darrah of Gettysburg, Pennsylvania kindly verified the identification of several species.

Figure 2. Larksville mine fire excavation showing hydraulic quenching of burning coal in the debris. The mine fire is under the rock on the right and the sand barrier is on the left.

Table 1.—Preliminary list of fossils from roof rocks of the top split of the Ross anthracite seam at the Larksville mine fire excavation, Larksville Boro, Luzerne County, Pennsylvania. Llewellyn Formation.

Lepidodendreae (Giant Club Mosses-Bark unless otherwise noted)
- *Eulepidophloios laricinus* (Sternberg, 1825)
- *Lepidocarpon linearifolium* (Lesquereux, 1879-1880)-Cone
- *Lepidodendron sicatum* (H. Bassler, 1919)-Megaspore
- *Lepidodendron brittsii* Lesquereux, 1879-1880-bark and leaves
- *Lepidodendron latifolium* Lesquereux, 1879-1880
- *Lepidodendron rimosum* Sternberg, 1820 (*Figure 4*)
- *Lepidodendron scutatum* Lesquereux, 1879-1880
- *Lepidodendron veltheimianum* Sternberg, 1820
- *Lepidodendron* sp.
- *Lepidophylloides* sp.-leaves
- *Lepidostrobophyllum lanceolatus* (Lindley & Hutton, 1831)-cone leaves
- *Lepidostrobophyllum "majus"* (Brongniart, 1828)-cone leaves
- *Lepidostrobus* cf. *princeps* Lesquereux, 1866-cone
- *Lepidostrobus* sp.-cone
- *Sigillaria laevigata* Brongniart, 1828
- *Sigillaria ovata* Sauveur, 1848
- *Stigmaria ficoides* (Sternberg, 1820)-root stock and rootlets

Calamarieae (Horsetails)
- *Annularia radiata* (Brongniart, 1826)-leaves in whorls
- *Asterophyllites equisetiformis* (Schlotheim, 1832)-leaves in whorls
- *Calamites (Mesocalamites) carinatus* Sternberg, 1823-pith cast
- *Calamites (Mesocalamites suckowi* Brongniart, 1828-pith cast
- *Pinnularia* cf. *columnaris* (Artis, 1825)-rootlets

Gymnospermous Seeds
- *Cornucarpus* sp.
- *Trigonocarpus* sp.

Sphenophylleae (small herbaceous plants)
- *Sphenophyllum emarginatum* Brongniart, 1828
- *Sphenophyllum majus* (Bronn, 1828)

Neuropterideae (seed ferns)
- *Neuropteris ovata ovata* Hoffman, 1826 (*Figure 3*)
- *Neuropteris ovata* forma *fimbriata* (Lesquereux, 1858)
- *Neuropteris ovata* forma *flexuosa* Sternberg, 1826
- *Neuropteris rarinervis* Bunbury, 1847
- *Neuropteris scheuchzeri* Hoffman, 1826
- *Neuropteris (Cyclopteris) trichmanoides* (Brongniart, 1828)

Alethopterideae (seed ferns)
- *Alethopteris* sp.
- *Alethopteris* sp.

Sphenopterideae (seed ferns)
- *Sphenopteris* cf. *speciosa* (Lesquereux, 1879-1880)
- *Sphenopteris squamosa* (Lesquereux, 1854)
- *Sphenopteris* sp.

Pecopterideae (seed ferns)
Pecopteris (Asterotheca) lamuriana Heer, 1876
Pecopteris sp.
Mariopterideae (seed ferns)
Karinopteris daviesii (Kidson, 1925)
Mariopteris nervosa (Brongniart, 1828)
Incerta sedis
Myeloxylon sp. (medullosan petioles)
Stigmarioides sp. (stem)
Serpulidae (worms)
Spirorbis carbonarius Dawson, 1868 on seed fern *Sphenopteris* sp.

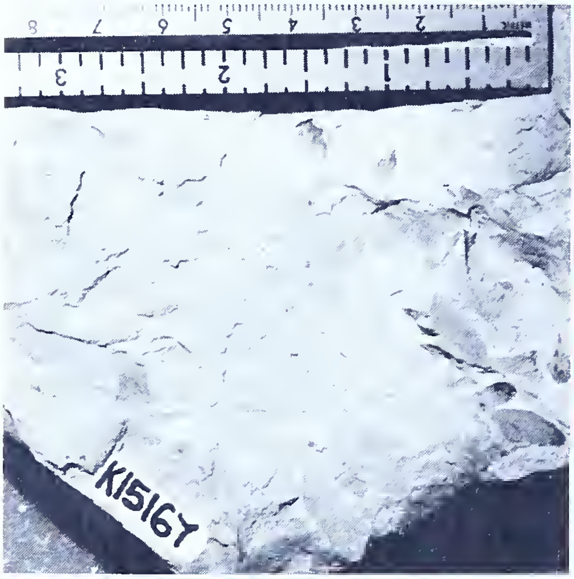

Figure 3. ***Neuropteris ovata ovata*** **Hoffman, 1826. This seed fern is the most common fossil at the mine fire site. Specimen has turned from black to yellowish-orange due to heat from mine fire.**

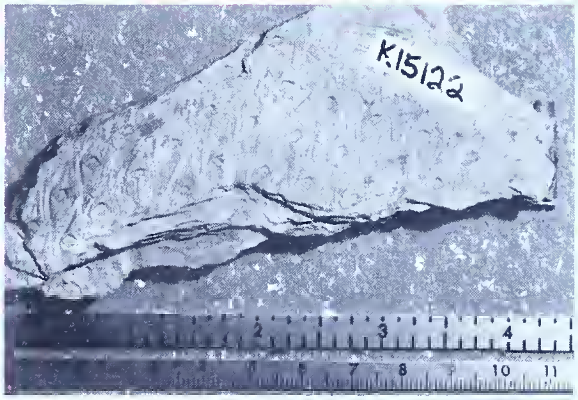

Figure 4. ***Lepidodendron rimosum*** **Sternberg, 1820. Large sheets of the bark of this Lycopod are occasionally found in the shale just above the coal.**

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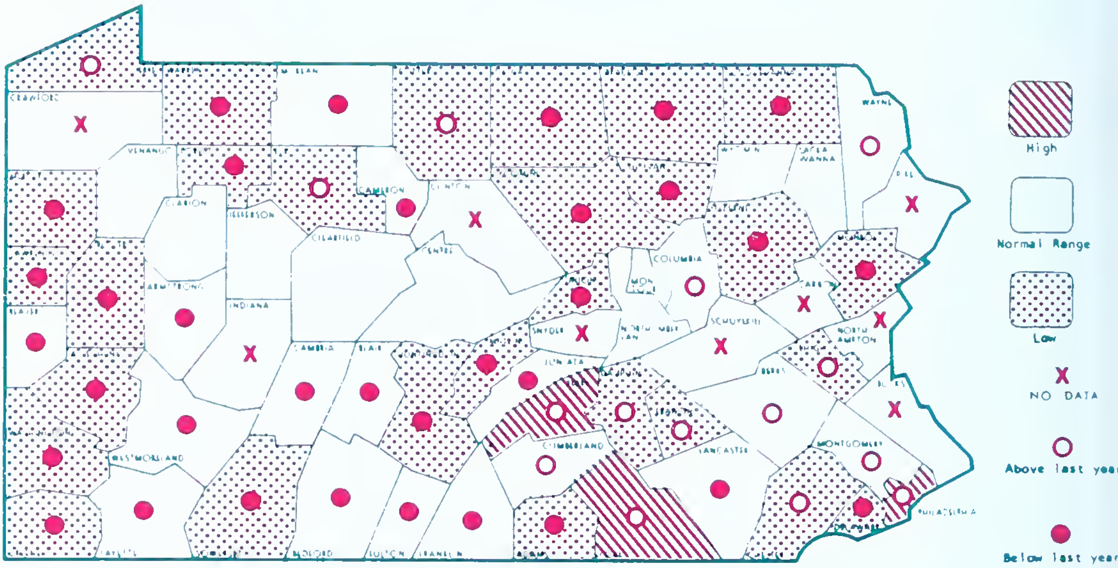

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